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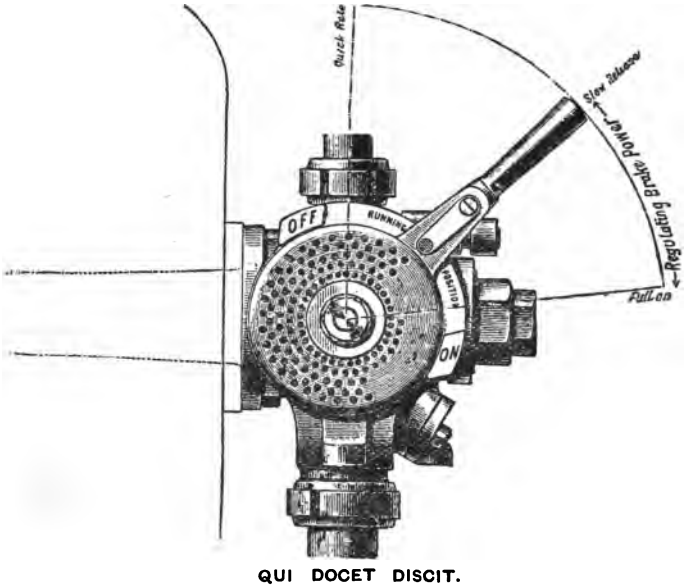

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By C. BRIGGS, Driver, G. N. R.

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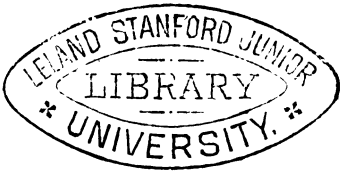

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PREFACE.

THE Author has endeavoured to make the subject of Simple and Automatic Vacuum as easy and interesting as he possibly could. The drawings are plain, and every particular point is marked and noted upon in the explanations, so that they are easily understood, even by the uninitiated. And, although the book is written especially for the benefit of the engine drivers and firemen on our railways, the traveller also will be interested and enlightened by its perusal. The Author has long seen the want of a book on the subject of Simple and Automatic Vacuum Brakes, as the instructions which are issued from time to time relating to the Brakes are vague and misleading to drivers, even if understood by them, and unless the driver has the ability to find it out for himself, he will search far before he finds anyone to explain it to him; but by the simple drawings and explanations herein set forth, I can say that if studied by them, all drivers may gain a fair knowledge of Simple and Automatic Vacuum Brakes, such as will enable him to cope with almost any difficulty which is likely to be met with in the course of his career as a driver. The writer, in conclusion, desires to express his indebtedness to the courtesy of his Superintendent, E. Drage, Esq., for his kindness in supplying him with drawings of the converting valve, and also suggesting the place they should occupy in this work.

CHRISTOPHER BRIGGS.

SIMPLE AND AUTOMATIC VACUUM BRAKES.

CHAPTER I.

The Superiority of the Modern Driver over the Past Generation of Engine Drivers—Reasons assigned to have produced this Improvement—How careful Drivers are to conceal the Secrets of their Knowledge—How to become Efficient Men—Simple and Automatic Vacuum: a Problem to most Enginemen—What a man should gain before he can have a Thorough Knowledge of Simple and Automatic Vacuum Brakes.

IN writing on this subject, I am endeavouring to benefit my fellow-workmen as far as it lies in my power to do so. We are well aware that the driver of to-day is far in advance of the driver of ten or twenty years back; yet there is plenty of room for improvement. In saying that the driver of to-day is superior to the driver of ten or twenty years back, I am not speaking of drivers individually, because at that time we know there were some as smart men as ever stepped on the footplate of a locomotive; but there must always be some who have missed their vocation, and consequently are not what you would expect a driver to be; but the bulk of drivers are far in advance of the bulk of drivers of twenty years ago.

We ask ourselves, whence this great improvement? There must be a reason for it; and, in my opinion, it is the result of two things, and those two things are: better education, and the assistance given in the way of obtaining knowledge by books written specially on the subject,—diverting the mind from chaotic confusion and pointing out the way to gain knowledge. An ignorant man is unable to grasp the problems connected with locomotion to the same extent as one who has had the advantage of a better education. The man who has learnt a little, wants to know more, and when he sees a thing working, he asks himself, "How does this work, and what is the power that works it?" and by this desire for knowledge he is glad to come across something which will help him to solve the problem. But how carefully he guards this secret when he has once found it out. He guards it with a miser's

care; not even will he tell his own mate, for fear he should tell someone else, and his knowledge thus become common property. He may be free in spending his money, and will stand treat for his friends, but these secrets he keeps locked up in the treasure-house of his brain, where he nurses them and gloats over their worth.

But there are men rising up here and there amongst enginemen, who have a desire to see all enginemen possessed of a thorough knowledge of the locomotive and the steam engine in general; and I may here mention that Michael Reynolds, the pioneer in this class of railway literature, has done more to advance the knowledge of the modern driver, by his work on the management of the locomotive, than even education. He treats, in this work, on almost every difficulty which is likely to be met with in the course of a life on the footplate of a locomotive; but I have reason to think that the existence of this admirable book for enginemen is not so widely known as it should be, else why these complaints from locomotive superintendents of the lack of knowledge in mechanical subjects on the part of old firemen who go up to be passed for drivers? I am inclined to think that the drivers are loth to recommend this book, for fear the fireman should know or get to know as much as they do themselves. I am well aware that plenty of drivers have not yet got this (to them) necessary book, or otherwise they would be more up in the knowledge of the locomotive; and to these men I say, get it at once, and study it, and it will help you to become efficient men; ready when the time comes, as it surely will come, for enginemen to have certificates—aye, ready, I say, and eager to take a certificate of the first class.

The great problem which now occupies the mind of the engineman of to-day is, the simple vacuum brake, the automatic vacuum brake, and the Westinghouse air brake. These three air brakes are a puzzler to the generality of engine drivers, and they are anxiously trying to solve the problem. A man may learn to work any of these three brakes, and to stop at stations and signals with great precision, even as you can learn a monkey to do certain things when required; but if anything goes wrong with his brakework, he is flustered, and knows not what to do. Look at the Carlisle accident, and see the Government Inspector's Report to the Board of Trade, and then consider how many more such accidents might occur, if circumstances led up to it, by drivers who do not understand these brakes, and the laws which govern their motive power.

I intend treating, in this work, on the simple vacuum and the automatic vacuum brakes. How often does this subject occupy the mind of the driver of to-day? To the man who has a desire to be efficient in his work, it is never absent from his mind. Well, and what is this vacuum, which so occupies

the mind and distracts the thoughts of the engineman? Well, reader, to understand thoroughly this subject, we must have some knowledge of the atmosphere, or air, and the laws which govern it, just the same as to have a thorough knowledge of the working of the steam engine, we must understand steam.

CHAPTER II.

Air and its Constituents—Distance to which the Atmosphere extends into Space—Its Pressure upon the Earth—Weight of each Cubic Foot—Difference between Gases and Liquids—What is meant by Elasticity—The Close Resemblance of Air and Steam—Liquid not Compressible—How to Test the Upward Pressure of the Atmosphere—Proof of Damp Air being lighter than Dry—Experiments with Air and Water—Electricity, and how the Air is held close to the Earth—Nature's abhorrence of a Vacuum—Velocity of Sound and Light—How a Vacuum is created by the Discharge of a Gun.

AIR, as it is commonly termed, is composed of three gases, in the following proportions in one hundred parts:—

NITROGEN - - -	79 PARTS.
OXYGEN - - -	20 PART.
CARBONIC ACID GAS - -	·04 PART.
MOISTURE - - -	- 1 PART. (A varying amount.)

Now this vast sea of gases extends into space for a distance of from forty-five to fifty miles, and each cubic foot of these gases weighs about one and a quarter ounces, and the whole mass presses on the earth with a pressure of fourteen pounds and seven-eighths of a pound to the square inch, or very nearly fifteen pounds to the square inch.

Now what are the properties of gases, and what is the difference between gases and liquids? You must understand that these gases, like steam, are elastic, steam being also composed of gases. Well, and what do we mean when we say such and such a substance is elastic? It would be no use me trying to explain the action of steam in the cylinder of a locomotive by telling a man that the steam was cut off at two-thirds of the stroke, and allowed to do the other part of its work by its elasticity, if the man did not understand steam and what was meant by elasticity; so that when we say such and such a thing is elastic, or such and such a substance is elastic, we mean it can be compressed to a certain extent, and if the pressure is taken off, it will expand, because each atom of gas repels the other, and tries to get as far away from it as possible. Upon this principle the Westinghouse air brake is worked—namely, by compressed air. If we had, for instance, say, a boiler two feet diameter, filled with steam at a pressure

of one hundred pounds to the square inch, and we were to take the pressure off by admitting it into a boiler twenty-five times as large, it would fill up the whole space in the big boiler, but it would have lost its pressure, which shows it is an elastic substance, or gas, so that air and steam have a very close resemblance to each other. Now, in liquids this compression is impossible, because you cannot compress them to any extent. Consequently liquids have only a pressure equal to their own weight in vacuum, and are not elastic, which you can easily prove by half filling a glass with water, and exhausting the other part of the glass of air, which is pressing on the water in the glass with a pressure of fifteen pounds to the square inch, and still the water in the glass will only occupy the same space as it did when the pressure of the air was upon it, thus showing that it is neither elastic nor compressible. So that we see the two different properties of water and steam: heat turns the water into vapour, or gas, which is compressible; and heat will also raise the pressure of the air if confined, in just the same manner as it will raise the pressure of the steam. We often hear people say, on a damp or foggy day, that the air is very heavy, when, in fact, it is lighter than when it is dry. For instance, the air, when dry, will support a column of mercury thirty inches high; but, in damp or rainy weather, the mercury sinks lower in the glass, thus showing that some of the pressure has been taken off, which conclusively proves that the damp air is lighter than the dry. Now, on the other hand, had the water been exhausted from the glass by a tap at the bottom of the glass, the top of the glass being made air-tight, the air which was in the glass would have expanded and filled the glass; but you must not therefore run away with the notion that you can seal the top of the glass air-tight and draw off the water at the bottom in the open atmosphere, as this is impossible, the pressure of the air underneath the glass being as great as the pressure inclosed within; therefore, if you wish to exhaust the water from the glass, you must exhaust it into a vacuum, so that you would have to exhaust another glass of air, having the tap of the water glass fixed in it. If you now open the tap in the water glass, the pressure of the air above the water and its own weight will at first cause it to flow out very rapidly, as the air expands in the glass by its elasticity.

The enquiring reader will have asked himself, How is it if these gases, or air, are so elastic or expansive as you make them out to be, they don't fly off into space, where there is no pressure against them? Well, reader, that involves another law, what Sir Isaac Newton termed the law of gravitation, but what in this case would be more aptly termed the law of attraction, and to explain this law we must go a little way into electricity. You must know, then, that the earth is a large magnet, and attracts all substances which are in close

proximity to it, the same as a loadstone will attract a needle. The earth attracts the air by its magnetism, and keeps it from flying off into space, and its magnetic power may be surmised when we know that it exerts its influence on other planets millions of miles through space; in fact, the whole of the stars and planets which we see in the heavens are upheld by this mysterious electrical power of attraction and repulsion, and to this power we are indebted for our different seasons of winter and summer, which are brought about by attraction and repulsion of other planets. by making this our earth rotate on its axis as regularly as though it were governed by clockwork. So now you will see why this air, or atmosphere, is held close to the earth, and presses upon it with all its weight, filling up every available place; in fact, it is said that nature abhors a vacuum, or empty space, and the whole body of the atmosphere uses all its influence to fill up those empty spaces, pressing upon them from all sides with its pressure of nearly fifteen pounds to the square inch; and as we were speaking of the expansive or elastic properties of the air, you must know that the air has as great an upward and side pressure as it has downward pressure. To prove this, you have only to get a tumbler-glass and fill it with water, then place on the top of the glass a piece of writing-paper, or cardboard, which will cover it, hold the paper close to the glass, and turn the glass upside down; now remove your hand, and the upward pressure of the air pressing on the paper will keep the water in the glass. Well, how are we to explain this? To satisfy our minds that this is so, the mind needs proof and explanation to satisfy it, and we must explain it in this manner: The glass is a firm substance, capable of resisting a certain pressure, therefore the bottom and sides of the glass sustain the downward and the side pressure of the air, and the upward pressure keeps the water in the glass by pressing on the paper, showing that the air exerts its pressure on all sides equally.

Then see how quickly the air fills up a vacuum. If you have ever noticed the discharge of a gun, you will have noticed that the report is almost simultaneous with the discharge, that is, if you are standing close by; but if you are at a distance from it, you see the flash before you hear the report. But you must bear in mind that light travels three times as quick as sound, so that light travels three miles in the time it will take sound to travel one. Many imagine that it is the powder which makes this report, but this is not so. The powder when it rushes out from the barrel of the gun displaces the air, and causes a vacuum, and the air from all sides rushes into this empty space, meeting together with a loud report; the loudness of the report, and consequently the distance to which it can be heard, depending on the amount of explosive used and the resistance it has met with, causing a greater or lesser vacuum.

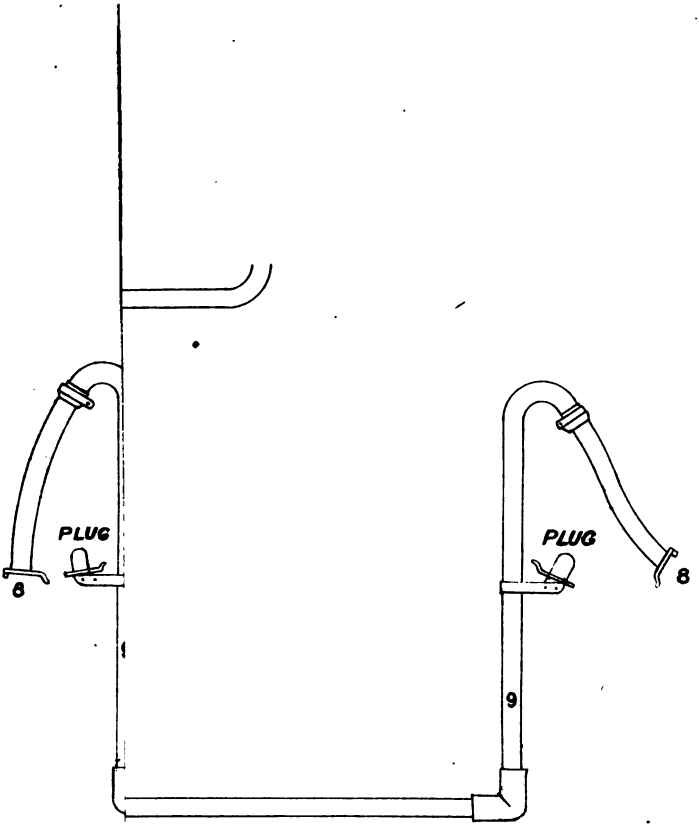
And now the reader will understand something about the

introduced as a vacuum chamber for the vacuum

brake. This was rather an inferior kind of apparatus for this brake, which was soon proved, little holes getting worn in the bellows, causing leakage, and consequently an imperfect vacuum. Naturally, this caused a lot of expense in examining bellows to find where the leakage was, and repairing; and as it is with all kinds of inferior apparatus in this age of progress, it was soon superseded by more reliable apparatus, which was cheaper in the end, and gave better results, being much less liable to failure, and lasting a great deal longer than the old bellows, which was almost always leaking somewhere or other. Almost all patents are imperfect at first, but once launched in the public market, they are quickly improved upon, either by the patentee or some other enterprising individual; so that, if once given the idea, they are almost always brought to perfection. But to return to our diagram (fig. 1). This casing is made of iron, and has a pipe running up the side to the top of the casing, which connects with the inside of the vacuum chamber or bellows, and connected to this pipe, at the bottom, is another small indiarubber pipe, used for the purpose of flexibility, to make the connection between the main air pipe and the vacuum chamber; and on each engine there are at least two of these vacuum chambers, one under the tender, and the other under the footplate of the engine; and there is also a spindle connected to the bottom of each bellows, and connecting with the engine and tender brakework respectively by suitable brake rods, which are fastened on to the journal or shaft of the brakework. Fig. 2 is a section of the main air pipe, which is fastened on to the front buffer-plank of the engine by a clamp. You will notice this pipe comes over with a curve or bend at its extremity, and to this part is fastened a flexible indiarubber pipe, strengthened with a spiral wire placed between the inner and outer coats of indiarubber, which makes it very strong, and only slightly interferes with its pliability. The pipe is wrapped firmly round at the joint by stout copper wire, which ensures it being thoroughly air-tight, and at the extremity of the indiarubber pipe is a cap, secured in the same manner by a strong copper wire. Inside the rim of this cap is an indiarubber washer, and there is a half hook, or horn, cast on this cap for the purpose of coupling it on to the train-pipe, or solid plug marked A, which is fastened on to the main air-pipe by a clamp opposite the extremity of the pipe. Fig. 3 is another section of the main air-pipe which connects with the vacuum chamber, and extends up to the release-valve, and is provided at its lowest extremity with a drip valve-box, to drain away the condensed steam which finds its way into the pipes from the ejector valve box. Fig. 4 is another part of the main air-pipe, to which is connected the ejector and the exhaust valve-box and pipe which runs along the side of the engine boiler and enters the side of the smoke-box, terminating in a curve

which points up the chimney or funnel of the engine. Fig. 5

air-chambers of air by drawing the air out along the



is created, fills it up. The plunger, as it rises, forces out the air

which points up the chimney, or funnel, of the engine. Fig. 5

air-chambers of air by drawing the air out along the pipes, 9 9 9 9 9, which connect with the vacuum chambers by the pipes E E. Upon the application of steam from the ejector, the vacuum chambers are rapidly exhausted of air, and the atmosphere, having free access to the end of the bellows, exerts its full pressure of almost fifteen pounds to the square inch on the bottom of the bellows, forcing it up to crush out of existence this vacuum which is being created, and the spindle of the bellows, being connected with the brakework by the levers A A, it slightly twists the journal to which the brake rods are attached, thereby pressing the brake blocks on the wheels with great pressure. The application and effect is instantly felt by the check it gives to the momentum of the engine or train, whichever it may be; in fact, the air exerts its influence instantly with the application of the steam, if pipes and valves are in good order. So soon as the application valve is shut off, the valve ball G rolls back on to its seat, preventing the air from getting into the main air-pipe and destroying the vacuum which has been created. To release the brake, you simply open the release-valve (No. 4) by raising the handle, when the air immediately rushes down the pipe and into the vacuum chambers, destroying the vacuum and equalising the pressure on the bellows, which, by gravity, then assumes its original position, the brake blocks also falling off the wheels by the same law. This is a great improvement on the old hand-brake, because you can release and apply the brake several times in a minute, which is a great advantage in stopping a train, enabling one to run up to a station with perfect safety at a greater rate of speed than was ever dreamt of in the days of the old hand-brake.

CHAPTER IV.

Showing old Concertina Bellows worked by a Hand-Pump, also how the Air acts on the Bellows at every stroke of the Plunger—What is meant by Collapsing of the Bellows.

BUT, in order to give my readers a thorough knowledge of vacuum, I have here appended a simple illustration of an old concertina bellows, to be worked by a hand-pump, and also fitted with a release valve and pipe, and you must understand that a vacuum can be created just as well by a pump as by a jet of steam, and, in my opinion, the pump is preferable to a steam jet. A, then, in the illustrated diagram (fig. 3) is the barrel of the pump, intersected at B, and fitted with a disc-valve, which opens when the plunger C of the pump is raised. This plunger, being made perfectly air-tight, leaves a vacuum behind it, and the air in the bellows, by its elasticity, follows up the plunger, and, as fast as this vacuum is created, fills it up. The plunger, as it rises, forces out the air

improvement has been made here; the old concertina bellows has disappeared, and in its place we have two cylinders and pistons. The piston rods are made

of brass, and work through brass rings; you will also notice that the ejector and exhaust valve-box have been carried to the smoke-box end of the engine boiler, the driver opening the application-valve by a rod, or lever, which runs along the side of the boiler, terminating with a handle inside the cab, and within easy reach of his hand. This brake is applied and released in the same manner as the other, but the driver has only the release-valve and the application-valve handle inside the cab, whereas in the other drawing he has the whole paraphernalia inside the cab, sometimes to his great inconvenience, especially if some of the joints happen to be blowing. In place of the old concertina bellows there is a diaphragm of indiarubber, fitted round the head of the piston, and also fastened securely to the casing, which used formerly to protect the bellows only, but which now answers the same purpose as a cylinder, the indiarubber diaphragm doing duty as a piston head.

Technical description of the uses of each part.—A is the application handle, screwed on to the rod which runs alongside the boiler, and connects with an upright arm, this arm being connected to the spindle of the ejector valve S, and also to the crank cast on the ejector valve-box, from which it obtains its fulcrum when the driver opens the valve, by pulling the handle A. R is the release-valve, fixed on the top of a pipe connecting with the main air-pipe. You will notice the valve is in a horizontal position, and it has on its underside a lead washer. This valve has an advantage over the other one, as there is its own weight in addition to the pressure of the atmosphere to keep it on its seat, and the handle can also be brought further out in the cab, so that the driver can reach it with his hand when he is looking over the side of the cab, or, as it is more commonly called by enginemen, the weatherboard side. E is the ejector valve-box, which is placed on the top of the boiler, near to the smoke-box of the engine, and B is the ejector-pipe which connects it with the exhaust valve-box F. This contains a ball valve G, which is represented on its seat, the valve-box being fitted or connected to the main air-pipe. D D D are the drip-valve boxes. These valve-boxes are for the purpose of draining away the water which may find its way into the pipes from any source whatever, and it is necessary that the perforated plug at the bottom, and also the ball valve, should be seen to and cleaned, say, once a week. We can often hear drivers say, "I don't know how it is, but she doesn't hold her vacuum as she ought to do." These drivers never think of looking at the drip-valves and cleaning them, neither do they know whether they are worn and want renewing or not; in fact, you never see such a thing in the report book as drip-valves changing, when fresh valves would make her as tight as a bottle, and the driver would not have to complain of her losing her vacuum too

quickly. O O are the cylinders, and L L are the flexible pipes connecting them with the main air-pipe M. The bottoms of these cylinders are perforated, that is, they are pierced with small holes to allow the air free power on the underside of the diaphragm. X is the exhaust-pipe, passing from the exhaust valve-box to the smoke-box end of the engine. To apply the brake, you pull the handle A, which opens the ejector-valve, admitting steam along the pipe B to the exhaust valve-box F, which is fitted with ball valve, having a partly horizontal movement. The steam passes through this valve-box and up the exhaust-pipe X into the smoke-box, and thence up the funnel, and by its suction draws the valve G off its seat, also drawing out the air along the main air-pipe M. The air, by its elasticity, assists the steam in doing this, and as the air is drawn out from the topside of the diaphragm, the pressure of the external atmosphere on the underside of the diaphragm forces it up towards the top of the cylinder, trying to crush out of existence the vacuum which is being created. I have heard the expression used by those who certainly ought to know better, that for one moment after the collapse of the bellows, or sack, the air remained passive, and had not exerted its pressure or influence on the bellows. This shows their ignorance of the subject on which they are speaking, and I would advise them to leave it alone until they have studied the laws which govern the atmosphere, when they will see the absurdity of their assertions; and, as this view of the subject is held by a great many drivers and firemen. I think it will be an advantage to my readers to analyse or reason it out, and thus settle the question by common reason.

We will suppose then, for instance, we have a bellows filled with air of the ordinary pressure of the atmosphere, or any other pressure which it is capable of resisting; we will take the bellows sealed up full of air, and place it in a glass cylinder, so that we shall be able to see its behaviour under the experiments through which we shall put it.

EXPERIMENT No. 1.—We will empty the cylinder of air by the use of an air-pump—the cylinder, mind, but not the bellows. Well, and what shall we observe? We shall see that the air which is contained in the bellows has pushed out, or extended, the bellows to its greatest extremity, because there is no pressure on the outside of the bellows to resist the pressure inclosed within, and if the bellows was not sufficiently strong so as to resist this internal pressure of air, it would burst the bellows.

EXPERIMENT No. 2.—We will now exhaust the air from the inside of the bellows by means of the pump, and we shall observe that the bellows remains fully extended, as though it was filled with air. Well, how is it that this bellows has not closed up, or collapsed, the same as it does in the vacuum

brake when the air is extracted? Simply because there is no external pressure on it, and the bellows has no action of itself, but is actuated by the pressure of the atmosphere, just the same as the bellows, or diaphragm piston, or whatever it may be, is in the vacuum brake.

Then upon what theory do they base their assertion that the air remains passive one moment before exerting its influence after the collapsing of the bellows? Upon no theory at all, reader. It is simply an idea they have got into their head, and the sooner it is rooted out the better. If the air has not exerted its influence on the bellows, how is it that it has collapsed, and what has caused it to collapse? We have seen that the bellows we have been experimenting with will not collapse in a vacuum, and the only power which can cause the vacuum brake bellows to collapse is the atmosphere.

But to return to our drawing. When the driver shuts off the application-valve, the ball-valve G rolls back on to its seat in the same manner as the one previously described, closing the inlet to the main air-pipe, and preventing the atmosphere from destroying the vacuum. To release the brake, you raise the handle of the release-valve R, and allow the air to enter the main air-pipe, through which it instantly reaches the vacuum chambers, destroying the vacuum and equalising the pressure on the diaphragm, which, by gravity, then assumes its original position, which is almost at the bottom of the cylinder, or casing, the brake blocks also falling off the wheels by law of gravitation.

CHAPTER VI.

Tell-Tale Vacuum Engine—Its Superiority over other Simple Vacuum Brakes—Combination Ejector—How a Partial Vacuum is maintained throughout the whole system—What Drivers want—Why the Simple Vacuum is being discarded and the Automatic Vacuum adopted.

THESE are two of the simplest kinds of vacuum brakes, which we have previously noticed, but there is yet another kind of vacuum brake, which is termed the tell-tale vacuum brake. This is an improvement on the two previously described, inasmuch as it indicates when pipes and valves, &c., are in good order, or *vice-versa*.

Diagram No. 5 is a drawing of this brake on engine and tender. You will notice in this brake that the diaphragm of indiarubber is still retained, showing that it has proved itself a reliable invention. You will also notice that the ejector valve-box and release-valve are all combined and worked by one handle, and, by means of the combined tell-tale ejector, a partial vacuum is maintained throughout the whole system, namely, in the main air-pipe and tops of cylinders.

The Vacuum Brake Company explain the drawing in the following manner:—By means of a small ejector, known as a tell-tale ejector, a partial vacuum is maintained throughout the system, *i.e.*, in main train-pipe and tops of cylinders, but to such a slight extent only as will not affect the brake. So long as the vacuum remains intact, the gauge upon the engine and in the vans will indicate "brake right," but should a leak occur of such a nature as to render the brake unreliable, the small ejector will fail to maintain the vacuum, and the gauge will immediately show "brake wrong," so that drivers and guards are prepared to act accordingly. By this means, drivers and guards know the exact state of the brake power at their command. To apply the brake, the driver pulls the lever of the ejector upon the engine from running position to position marked "brake on," when the large ejector is brought into play, creating a high vacuum, and the brakes are applied. This form of brake, indicating as it does its exact state of efficiency, is only one step removed from the automatic brake. Although the guard cannot apply the brake himself, he can, nevertheless, signal to the driver to do so by means of a gong in connection with the partial vacuum in the main train-pipe. The same may further be readily used as a means of communication for passengers. The diaphragm and the flexible pipe to cylinder are made of the best rubber, and coated with a material which effectually resists oil and grease. Now this is where most of the trouble begins with drivers, because, as I have said previously, no two companies use exactly the same kind of apparatus, in fact, you will find different mechanisms employed by the same company on different engines, and this is not a sufficiently lucid explanation for a driver. It will do very well for boards of directors and the travelling public, but a driver wants a thorough knowledge of the inner working of the brake, so that if anything goes wrong he knows in a moment what it is, and how to act; knows whether he is able to put it right himself, or whether it must be left for other workmen; and this work is to give to enginemen that inner knowledge for which they are seeking, or to assist them in finding it out for themselves, by giving them a thorough knowledge of the subject of simple and automatic vacuum.

This description of the Vacuum Brake Company is rather misleading to drivers of engines who would like to thoroughly understand the brake and its inner working, and, to their praise be it said, there are few but what are seeking this knowledge. But the driver looks in vain for this small ejector which is spoken of in the Brake Company's circular; and, failing to find it, he abandons the study of the inner working of the brake and the meaning of the Brake Company's circular as too vague for him to understand. Mind, I do not

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say this of all drivers, because there are plenty who have a very good knowledge of both the simple and automatic brakes, but the generality of drivers are in the position described above. Now the fact is, when he turns on the steam from the boiler to the ejector valve-box, this small ejector which is spoken of in the circular is at work, as the ejector-valve is never entirely shut off, but very nearly so, thus allowing a small amount of steam to pass through the ejector into the exhaust-pipe, which creates a small amount of vacuum in the tops of cylinders and in the train-pipe, probably two or three ounces, that is, it reduces the pressure of the air contained in the cylinders and train-pipe two or three ounces below the pressure of the external atmosphere, which is not sufficient to raise the brakework, but answers the purpose for which it is intended, *i.e.*, that of indicating whether pipes, joints, &c., are all in good order, the which it would soon show by the indicator turning to "brake wrong" if there were any leakage in pipes or cylinders.

The Vacuum Brake Company claim for this brake that it is only one step removed from the automatic vacuum, but that one step is the all-important one, for this reason, if anything happens to the brakework through the train breaking loose, or some other part giving way, the brake is of no use, hence the companies have wisely almost discarded this brake, giving preference to the automatic vacuum, which, if manipulated properly, is a reliable brake under all circumstances.

Technical description of the Tell-tale Vacuum Brake and Combination Ejector.—You will notice that the steam to work the ejector is here taken from the dome, the highest part of the boiler, by a pipe which runs along the inside of the boiler to the front of the fire-box, and connects with the steam valve-box S, so that the steam is kept heated and dry right up to the point of admission, thereby reducing the condensation of steam to a minimum. Before leaving the engine at the shed, the steam-valve must always be shut off, so that the pipes may be kept as dry as possible, ready for the next trip, and when the driver comes on duty the next day, or whenever it may be, he should not open the steam valve until there is at least a pressure of sixty pounds to the square inch of steam in the boiler, for this reason, if steam is admitted to the pipe which supplies the ejector at a low pressure, it is more easily condensed, leaving a greater quantity of water to be got rid of before joining the train, which must always be done; and it should not be done so that all the dirty water falls on the newly-cleaned boiler and other parts of the engine, neither should it be done, as I have often seen it, when passing through a station. The driver may perhaps find it more convenient to him to do it there, but he would not like it were he a passenger standing on the platform, and all the dirty water fell on his clean linen, bespattering him all over. The best time to get rid

of the dirty water which has accumulated in the pipes when the engine has been standing in the shed is, when leaving the shed, if you are running tender first; if not, leave it until you are backing on the train, or at some other convenient point, but do it before joining the train, using the hand-brake to stop the engine until you have a chance to get rid of it neatly. We will assume that the driver has come on duty, and is about to leave the shed; his steam gauge shows, we will say, one hundred pounds pressure in the boiler. He opens the steam valve S by turning the wheel, or tap, when steam is admitted to the pipe which supplies the ejector, and immediately the vacuum indicator turns to "brake right." If pipes, &c., are in good order, as they should be, this shows the driver at once whether his engine brake is all taut and trim, ready when the time comes for him to work it. Next we come to the ejector valve-box. The engine is leaving the shed, and it is convenient to get rid of the dirty water which is lying in the exhaust-pipe, &c., and which the small ejector is unable to clear out: he pulls over the handle to position marked "brake on," which admits steam to the large ejector; the steam then rushes with great force through the ejector and along the exhaust-pipe, carrying the water which is in the pipes along with it, and projecting it clear of the engine. As soon as the handle has been pulled to position marked "brake on," it is quickly pushed back to position marked "brake off," and, if the driver thinks he has not got rid of all the dirty water, the process is repeated, when the pipes, &c., will be all dry and clean ready for joining the train.

But to give a better understanding of the inner working of this brake, the reader had better examine the diagram No. 5, as he reads the following description:—E is the steam-pipe leading to the steam-valve S, Q is pipe from steam-valve to combined ejector valve-box M, and X is the exhaust-pipe; W is the main air-pipe, to which the cylinders are connected by small flexible pipes of indiarubber, similar to those given before in other drawings, but not convenient to be shown here; D is a drip valve-box under the footplate of the engine. This engine has four brake cylinders, 15 inches diameter, two of which are shown in the annexed drawing, and marked L L, the other two being fixed opposite them. When steam is turned on at the steam-valve S, which is fixed on the top, or front, of the fire-box, it passes along the pipe Q to the combination ejector M; the ejector-valve, having a slight opening to the ejector, it allows a small amount or jet of steam to enter the ejector, which, passing through, draws the exhaust-valve off its seat, and extracts a small amount of air from the train or main air-pipe, and consequently from the tops of the cylinders also. This is nicely adjusted, so that the jet can only maintain a certain amount of vacuum, not sufficient to affect

the brakework. When you wish to apply the brake, you pull the handle of the application-valve towards you, which further opens the valve of the ejector, allowing more steam to pass through, and consequently increasing the suction to a great extent, so that it rapidly draws out the air from the main air-pipe and tops of cylinders, creating a high vacuum on the topside of the diaphragm of all cylinders. The external atmosphere pressing on the underside of the diaphragms, or pistons, forces them up towards the top of the cylinders as quick as the vacuum is created above them, and with the well-known and suitable brake rods attached to the pistons and brakework, applies the brake almost instantly. When the handle is pushed back to its central position, he shuts off the steam of the large ejector, and, the small ejector being unable to maintain this high vacuum, the valve in the exhaust valve-box section of the combination ejector is forced back on to its seat by the atmosphere, closing the inlet to the main air-pipe and preserving the vacuum. When it is desired to release the brake the handle is pushed over to the position marked "brake off. By this action the air is allowed to enter the main air-pipe just below the exhaust-valve through the perforated disc, which supplies the place of the release-valve, which we have seen in other drawings which we have previously noticed, so that the brake can be released or applied with the same handle, which is a very convenient arrangement.

CHAPTER VII.

Why it is necessary for Engine Drivers to study Simple Vacuum as well as Automatic Vacuum—How Air and Steam resemble each other in their mechanical action—Technical Description of Simple Vacuum Train.

WE have only now to show our readers the working of a simple vacuum train of engine and carriages, and then, so far as simple vacuum is concerned, he should have obtained, if he has studied this book in addition to his observations when at work, a thorough knowledge of the inner working of the simple vacuum brake; and should it ever be the good fortune of engine drivers to have an examination to pass for a certificate as engineer, he should have no difficulty in passing well in this subject, if he has used his eyes and brain as he should do. Perhaps some of my readers may think it superfluous to go so thoroughly into the subject of simple vacuum, seeing that it is being gradually superseded by the automatic vacuum brake; but I have thought it necessary to go into this subject fully, so as to prepare the pupil's mind to grasp more readily the main subject, *i.e.*, automatic vacuum, and to see its advantages over the simple vacuum; and, in addition to this consideration, if ever drivers have to pass a Government

examination, they will be expected to understand thoroughly both the simple and the automatic vacuum brake, and to show the superiority of the one over the other, and also to describe the difference in working, and to explain why it has been found necessary to discard the simple vacuum and adopt the automatic vacuum. Therefore the reader should give his attention to the study of the simple as well as the automatic vacuum, so as to be in readiness to go in for his certificate and win when the time comes, which may be sooner than we expect.

We have seen that in all simple vacuum drawings the air has been drawn from the topside of the diaphragm, or piston, where one has been employed, and from an air-tight bellows where the concertina bellows has been employed, and the external atmosphere has had full and unrestricted power on the underside or bottom of the bellows, or diaphragm; and if a vacuum is created on the topside of the diaphragm, the atmosphere on the underside exerts its pressure of 15 pounds to the square inch on the bottom of the bellows, or the underside of the diaphragm, forcing it up to crush out of existence the vacuum, or inequality in nature, so that we see the action of the air in this and all other cases with regard to the vacuum brake is similar to the action of steam in the cylinder of a locomotive, or any other steam engine. If steam were admitted on both sides of the piston simultaneously at an equal pressure, it stands to reason that the piston would not move, but by having a vacuum, or a partial vacuum, on one side of the piston, and a pressure of steam on the other, the piston is forced on by the steam until this empty space has been filled up, or some other equalising force has balanced the inequality, such as, for instance, a heavy load, or train, behind a locomotive. And in just the same manner does the air exert its influence on the underside of the diaphragm or bottom of the bellows, in the vacuum brake when a vacuum is created on the topside, so that all we have to do to have a complete vacuum train is to provide cylinders and brakework to each carriage, and connect them with an air-tight pipe from the topside of the cylinders, and connect this with the main air-pipe on the engine, and we have a complete vacuum train similar to the annexed drawing.

Technical description of Simple Vacuum Train.—A is the steam valve admitting steam from the boiler to the combined ejector B, and C is the application-handle; D is the main air-pipe connecting with the combination-ejector and the main air-pipe, which runs along under the footplate of the engine and the body of the carriages. This pipe has a drip valve-box marked E at its lowest extremity, which is below all other parts of the main air-pipe and brake cylinders. G G G is the main air-pipe, which is fitted under the footplate of the engine and the body of the carriages, the brake cylinders being connected with it by the small flexible indiarubber pipes

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Simple V

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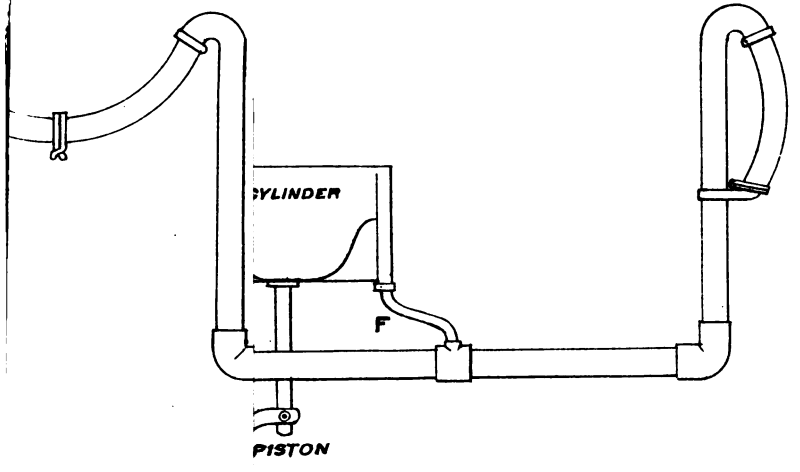


marked "brake on. When he wishes to release the brake, he pushes over the handle C to the position marked "brake off"

the body of the carriages, the brake cylinders being connected with it by the small flexible indiarubber pipes

marked F F F F, which connect the top part of the cylinders, *i.e.*, the part above the diaphragm, with the main air-pipe. When it is desired to bring the brake into action, you pull over the handle marked C, which admits steam to the combined ejector. Of course, assuming you have the steam turned on at the steam-valve A, the steam thus admitted is prevented from getting into the main air-pipe, as a great many people think it must surely do by the valve in the exhaust part of the combination-ejector, which is on its seat, closing the inlet to the main air-pipe, consequently the steam rushes along the exhaust-pipe marked L, and into the smoke-box of the engine, drawing by its suction the valve in the exhaust part of the combined ejector off its seat, also drawing the air out of the main air-pipe and top of each cylinder past the ball-valve and along the exhaust. This is not done as some people suppose, namely, the fore part of the train emptied first, and so on until it comes to the last part. This is not so. An equal vacuum is created in all parts of the train simultaneously, for this reason, so soon as ever you start creating a vacuum in any part of the train, the air from the other parts of the main air-pipe and cylinders follows up and equalises the vacuum in all parts of the train instantly, so that when a vacuum is created the brakework on all parts of the train is affected by it at once, and to an equal degree; and so when you pull the handle C, and thus admit steam to the combined ejector, it draws out the air from the main air-pipe and creates a vacuum on the topside of each diaphragm throughout the whole train, not in one or two cylinders, but in the whole batch of cylinders; and the external atmosphere having a free action on the underside of each diaphragm, or piston, forces each one up towards the top of its cylinder, endeavouring to crush out of existence its vacuum, and by the well-known and suitable brake-gear, which is separate on each carriage, and actuated by its own piston and cylinder, applies the brake-blocks to each wheel throughout the whole length of the train, with a force according to the amount of vacuum created to suit the circumstances of the case. The driver having full control in his own hands over the brake on all parts of the train, and when he considers he has a sufficient vacuum to suit his purpose, he pushes the handle back to its normal position, which is midway between the two extremes, that is, midway between the position marked "brake off" and the position marked "brake on," when steam is shut off from the combined ejector, and the ball-valve in the exhaust part of the ejector falls back on to its seat, closing the inlet to the main air-pipe and preserving the vacuum which has been created, and consequently keeping the brake-blocks pressed firmly to the wheels, and the vacuum indicator is in position marked "brake on." When he wishes to release the brake, he pushes over the handle C to the position marked "brake off"

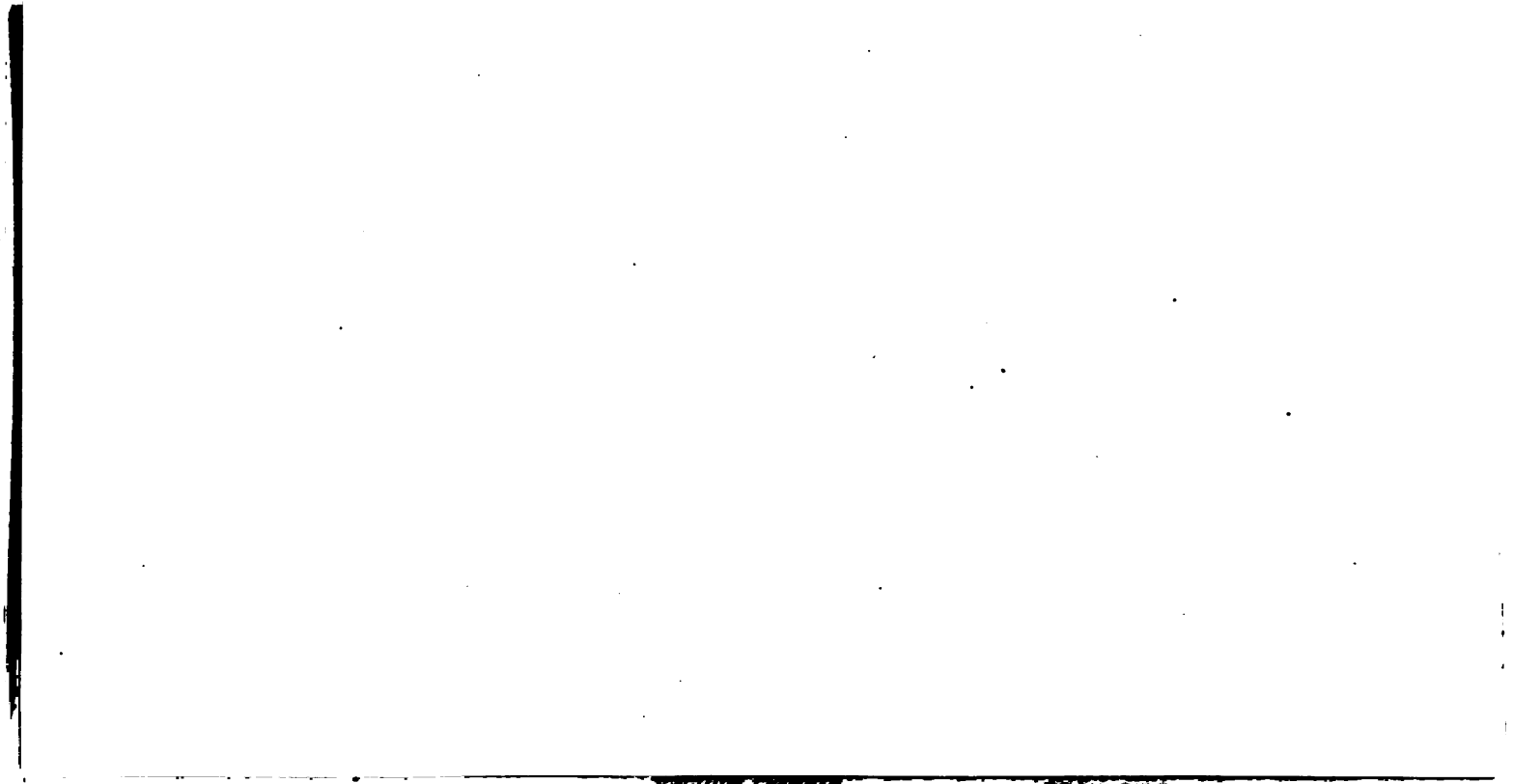
slowly, so as not to cause a jar to couplings and carriages, or wagons, if it be a goods train. When the valve, or disc, is moved to this position, the air enters the main air-pipe through the perforations in the disc immediately below the exhaust-valve, and rushes along the main air-pipe, destroying the vacuum in each cylinder, and equalising the pressure on each side of the diaphragm, when, by gravity, they fall into their original position, the brake-blocks also falling off the wheels by the same law.

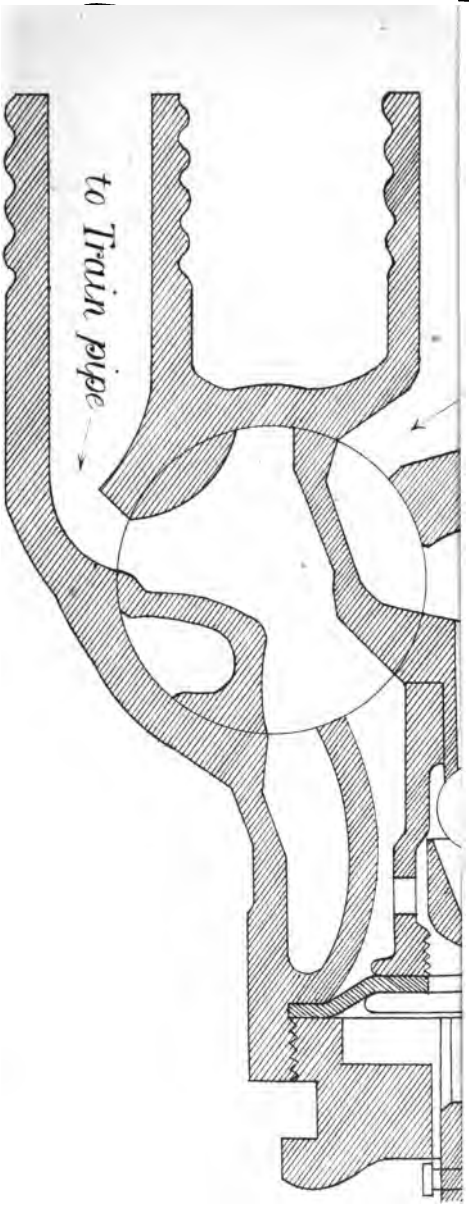
CHAPTER VIII.

Showing the difficulties which had to be overcome in the adoption of the Automatic Brake—Invention of the Converting Valve, and what it enabled the Railway Companies to do—Different Sections of the Converting Valve, and also Converting Valve set for both the Simple and Automatic Vacuum, also Engine Brake Cylinder and Vacuum Reservoir, fitted with Converting Valve, Ejector, and Application Valve.

HAVING noticed all that is necessary in simple vacuum, the question then arises as to how the companies managed to keep their carriages and engines running during the conversion of their brake from the simple to the automatic vacuum brake?

Anyone will be able to see at a glance that this was no small thing to undertake, after having almost all their stock fitted up with the simple vacuum. The brake did not come up to the requirements of the Board of Trade, and the companies were recommended to adopt a brake which should be automatic in its action, in case of damage to any of its parts, so the companies decided to adopt the automatic vacuum brake in its stead; and, therefore, it had to be considered how to accomplish this without having to stop all their engines and carriages for conversion at one time. And this difficulty was overcome by the invention of what is known as the converting-valve. By the use of this valve, a train can be worked either as a simple vacuum train or an automatic vacuum train; and, as the engines and carriages went into the shops for repairs, they were fitted up with one of these valves to each brake-cylinder; and when it so happened that a simple vacuum brake engine had to work one of these trains, by merely altering the conversion-valves the train could be worked as a simple vacuum train, which thereby came within the regulations of the Board of Trade, which states that all passenger trains shall be fitted and worked with a continuous brake. So that you will see how important a factor the converting-valve became in the conversion of our brakes, enabling the railway companies to keep almost the whole of


VACUUM CHAMBER
TRAIN PIPE



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No. 2. Set

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their stock running during the period that elapsed between the commencement of the adoption of the automatic vacuum until such time as all their carriages, &c, were fitted up with it.

Drawings of the Converting Valve in its different positions, showing the Valve set for Simple Vacuum, also reversed and set for Automatic Vacuum.—All the airways being specially marked and noted upon, the reader will easily understand its working arrangements. Diagram of converting-valve No. 1, showing interior arrangement, and set for simple vacuum.—B in the annexed drawing is connected to the main air-pipe by a small flexible indiarubber pipe, and in working simple vacuum, the air is drawn this way through the course marked S S S, which leads to the topside of the piston. When the valve is set in this position, *i.e.*, the simple vacuum position, the air is extracted from the topside of the piston only and the external atmosphere enters to the underside of the piston through the perforations in the converting-valve, which perforations will be noticed in other drawings of the valve, so that you will see that it is identical in its action with other simple vacuum drawings which we have previously noticed. You will also observe that all other airways, except this one marked S S S, are closed by the solid parts of the valve fitting over their openings; and, when it is required to set the valves for automatic train, the positions of the valves are altered by pulling a handle, which is fixed in a quadrant, and marked respectively S at one side of the quadrant, for simple vacuum, and at the other A, for automatic vacuum. There is one of these quadrants to each valve, the handle of which is connected to the valve itself by a rod, or lever; and when the handle is pulled over in the quadrant to automatic position, its action is communicated to the valve by this lever, and the valve is also moved in quadrant in a proportionate degree, and the valve is moved so that its solid parts are in the position of the annexed drawing, No. 2, set for automatic vacuum. The quadrants here spoken of were fixed on the side part of the carriage framework on the left-hand side of the carriage, and those on the engine are fixed, one on the front of the tender, and the other on the engine footplate, for tender and engine brake cylinders respectively. You will notice that when the valve is set in this, the automatic position, the direct airway from train-pipe to topside of piston is closed by the solid part of the valve, and the airway marked "To vacuum chamber" is opened to it, and if the valve is on the engine brake cylinder, this airway is connected to the auxiliary pipe by a small flexible indiarubber pipe, and by like means the one marked "To trainpipe" is connected to train or main air-pipe, and when the ejector is brought into action, the air from the topside of the piston is drawn through the auxiliary pipe direct, while that from the

underside of the piston is drawn through the main air-pipe, and thence through the auxiliary pipe's connection with it. But should a valve of this class be fitted on a carriage brake cylinder, there will be found under the body of the carriage, in addition to the brake cylinder, a vacuum reservoir, and this part marked "To vacuum chamber" is connected with it, and under these conditions in creating the vacuum, the air from both vacuum chamber reservoir and also underside of piston is drawn through the airway marked "To trainpipe," the air from the topside of the piston, and also vacuum reservoir, being drawn past the ball-valve, and that from the underside of piston through the airway to underside of piston, which is direct; and, in working the automatic brake after the vacuum has once been created on the topside of the piston and in the vacuum reservoir, it cannot be destroyed by the application of the brake, but is always kept intact until such time as the valve provided for the destruction of this vacuum is opened, when the air passes the ball-valve and destroys the vacuum in the vacuum chamber and reservoir.

Diagram No. 3 is a drawing of the converting-valve as it appears when fitted on the brake cylinder complete. R R is the point where it is bolted on to the brake cylinder, L is the reversing part of the valve to which the reversing lever is attached, G is the spindle which connects to the release-valve, N is the airway to train-pipe, and M is airway to vacuum reservoir, or auxiliary pipe, as the case may be.

Diagram No. 4 is a drawing in cross section of the converting-valve. In this section, the reader is enabled to view the part to which the reversing levers are attached for altering the valve to automatic vacuum, and also the perforations through which the air enters to the underside of piston when working simple vacuum. The lever for reversing is attached to the valve at D, and, when working simple vacuum, the external atmosphere enters to the underside of the piston through the perforations in the valve at L, and passes to the underside of the piston through N, while the air is extracted from the topside of the piston through E. To prevent the valve from overshooting either position in reversing, a quadrant is formed in the seating at A, and a projection of the valve fits into this quadrant, so that the valve can only be moved the distance of the quadrant, thus ensuring the valve being placed in the right position for whichever brake it is intended to use.

Diagram No. 5, drawing of reversing part of converting-valve in longitudinal section.—L is the perforated part of the valve through which the air enters when set for simple vacuum, and thence passes through N to the underside of the piston, while the air from the topside of the piston is extracted by the ejector through E.

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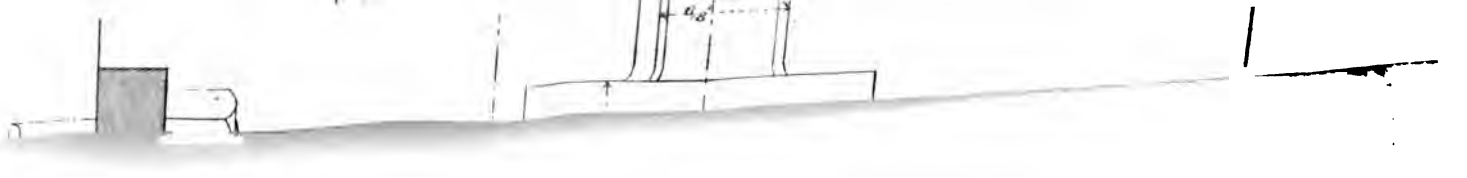
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1 3/4"
2 1/2"
P
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1 1/8"
R
9/16"

DIAGRAM No. 7

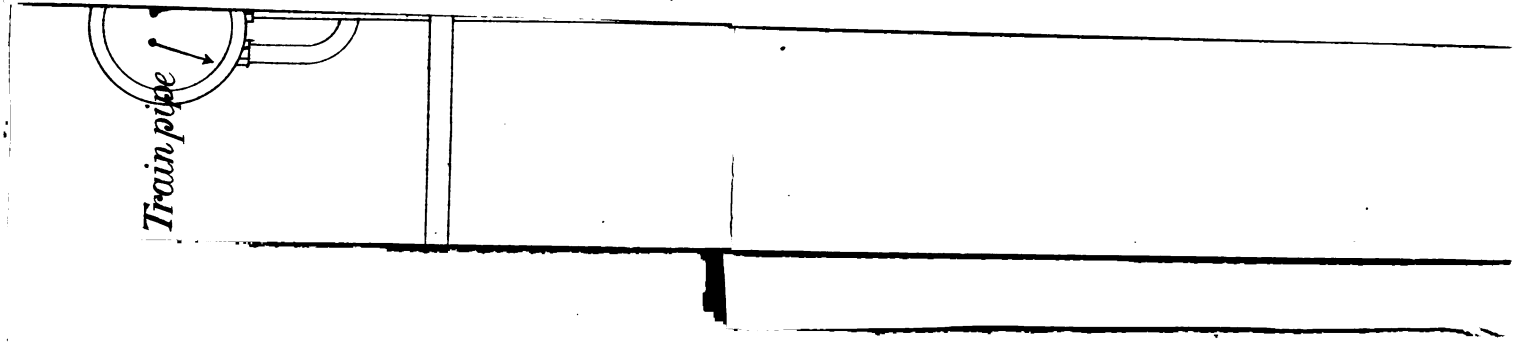


Diagram No. 6.—This is a drawing of converting-valve for carriage brake cylinder, having no reservoir. This valve has only one airway, marked S, which connects to the main air-pipe; there is also a spindle, which connects with the release-valve and to the lever R at the point P. The air from the topside of the piston, when working automatic brake, is drawn past the ball-valve, which is similar to the one we have before noticed, and, when once it has been extracted, the vacuum on the topside of the piston is kept intact; but should it be desirable to destroy the vacuum after this carriage has been placed in the siding, so as to release the brake, it can be done by pulling the lever R, which opens the release-valve, and allows the air to enter behind the ball-valve and destroy the vacuum in the vacuum chamber.

Diagram No. 7.—This is a drawing of an engine brake cylinder, and also vacuum reservoir, with the small maintaining-ejector and auxiliary pipe extending to brake cylinder and vacuum reservoir, also main air-pipe and application-valve, and showing the auxiliary pipe's connection with the main air-pipe.

Technical description.—In the annexed drawing, the reversing-cock, or valve S, at the bottom of the brake cylinder, is set for automatic action, and the vacuum is created and maintained by the small ejector A, which draws the air from the topside of the piston and vacuum reservoir along the pipe P, which is in direct communication with vacuum chamber and reservoir, while that from the underside of the piston is drawn along the main air-pipe, and thence through the auxiliary pipes connected with it at D. This connection is governed by a clapet-valve, which is here shown open, and is kept open by a prong which is fixed on the underside of the application-valve R, and, when the application-valve is shut, it rests on the lever of the clapet-valve, and thus keeps the auxiliary pipe's connection open to the main air-pipe.

EXTRACTS FROM THE BOARD OF TRADE RETURNS ON CONTINUOUS BRAKES FOR THE HALF-YEAR ENDING 30TH JUNE, 1890, WHERE THE MILEAGE RUN HAS BEEN OF IMPORTANCE, ILLUSTRATING THE FAULTS RECORDED AGAINST AUTOMATIC AND NON-AUTOMATIC BRAKES.

AUTOMATIC BRAKES.

WESTINGHOUSE AUTOMATIC BRAKE.

	Miles run.	Faults.
Eastern and Midlands	134,480	0
Great Eastern	4,980,944	98
London, Brighton and South Coast	3,502,073	23
London, Chatham and Dover	999,986	36
Midland	7,764	7
North Eastern	5,151,563	43
Rhymney	85,024	0
West Lancashire	113,198	0
Caledonian	2,993,357	20
Glasgow and South Western	579,362	18
North British	2,924,754	45
Great North of Scotland	276,050	1
East and West Junction	50,414	0
London, Tilbury and Southend	353,135	2
Hull and Barnsley	175,059	5
Castlederg and Victoria Bridge	8,608	0
Colne Valley and Halstead	14,000	0
Londonderry	19,824	0
Ayrshire and Wigtownshire	23,598	0
	22,393,193	298

AUTOMATIC VACUUM BRAKES.

	Miles run.	Faults.
West Clare	26,178	0
North Eastern	3,251	0
Great Western	7,818,200	56
Midland	6,539,807	6
Great Northern	4,457,328	79
South Eastern (Proportion)	1,351,556	16
London and South Western	4,468,436	31
Taff Vale	172,762	0
Great Southern and Western of Ireland	16,730	0
Belfast and Northern Counties	273,888	1
Aylesbury and Buckingham	11,160	0
Glasgow and South Western	839,594	4
Furness	211,448	0
Waterford and Limerick	23,282	0
Somerset Joint Committee	245,148	0
Mersey	108,297	1
London, Chatham and Dover	24,074	0
Cork and Muskerry	35,328	0
Highland	251,386	1
Manchester, Sheffield and Lincoln	1,669,110	7
Lancashire and Yorkshire	4,673,680	18
Cheshire Lines	845,752	6
London and North Western	5,823,654	125
Cavan, Leitrim, Roscommon	46,813	0
Seacomb, Hoylake and Deeside	75,279	0
Hull and Barnsley	1,488	0
North Stafford	133,800	0
Rhondda and Swansea Bay	13,456	0
Midland Great Western (Ireland)	76,672	0
Barry Dock and Railways Co.	23,353	0
Manchester, South Junction and Altrincham	3,908	0
	40,264,818	351

CLARK AND WEBB'S.

	Miles run.	Faults.
North London	895,183 ...	2

This shows for the

Westinghouse ... ... 1 Fault per 75,145 Miles run.
Automatic Vacuum Brakes ... 1 Fault per 114,715 ,,

NON-AUTOMATIC BRAKES.

CLARK AND WEBB'S.

	Miles run.	Faults.
London and North Western	765,918 ...	0
London, Tilbury and Southend	169 ...	0
Wrexham, Mold and Connah's Quay ...	8,733 ...	0
	774,820 ...	0

No failures reported.

SIMPLE VACUUM BRAKES.

	Miles run.	Faults.
*North Staffordshire	388,650 ...	0
*London and North Western	2,995,388 ...	9
*Manchester, South Junction and Altrincham	108,648 ...	0
Metropolitan	1,017,388 ...	8
*South Eastern (Proportion)...	1,351,556 ...	8
*Great Northern of Ireland	1,001,139 ...	0
*Great Southern and Western of Ireland ...	930,158 ...	2
Sligo, Leitrim and Northern Counties ...	15,308 ...	0
Belfast and Northern Counties	35,639 ...	0
*Dublin, Wicklow and Wexford	392,838 ...	2
*Midland Great Western (Ireland)	564,945 ...	0
*Cambrian	127,616 ...	0
Great Eastern	951 ...	0
	8,930,254 ...	29

*Converting the Non-Automatic Vacuum Brake into the Vacuum Automatic Brake.

WESTINGHOUSE (NON-AUTOMATIC).

	Miles run.	Faults.
Metropolitan District	756,226	No failures reported.

This shows for

Simple Vacuum Brakes ... 1 Fault per 307,940 miles run

Total miles run (Pressure Automatic and Non-Automatic), 23,149,419
,, (Vacuum ,, ,,), 49,195,072
,, (Clark and Webb's ,, ,,), 1,670,003

CHAPTER IX.

Different opinions of Drivers and others as to which is the best Brake—Is the Automatic Brake a Freezing Machine or not?—Misleading reports of the Press regarding the Automatic Brake.

HAVING gone through the simple vacuum and converting valve, the pupil's mind will be more readily carried on to the automatic vacuum than it otherwise would have been had he had no knowledge of the simple vacuum brake—the simple having in a manner prepared his mind to grasp more easily the main subject, and to see its advantages over the one previously discussed, and also to disabuse his mind of the many false illusions he is sure to have heard expressed by drivers and others who are interested in the simple and automatic vacuum and Westinghouse air brake. He will, I have no doubt, have heard it praised and disparaged; he will have heard it designated as a freezing machine by some, and as the best brake that has ever been invented, by others—and this opinion I can fully endorse. He will have heard the Westinghouse lauded to the skies by one, and the automatic by another; and his mind, perhaps, will have been swayed, first in favour of one, then back again to the other, according as the arguments have been forced on his mind by what have appeared to be solid facts, upheld by those who propounded them and argued on them.

The question, then, is, whether the automatic brake is a freezing machine or not? If it is a freezing machine, it is not a reliable brake; and if it is not a freezing machine, it is a reliable brake. Well, and how are we to prove it is not a freezing machine, or *vice versâ*? The man who alleges that it is, will say, by solid facts—that is, by the failures which have occurred and been recorded against it. I say, then, by all means let us discuss those facts. And, to begin, how often has it been recorded in the newspapers, that such and such a train, upon arrival at such a station, was unable to proceed on its journey for such a length of time, owing to the automatic brake being frozen, with the blocks bedded firmly to the wheels, and the driver and station staff were unable to release them for such a length of time; and almost all who read this statement set it down, without reason or thought, as another failure of this much-abused brake; and the Vacuum Brake Company silently bear the affront, for what reason I cannot say, unless it be they think that in time, as the people get more enlightened on the subject, the brake will speak for itself, and that they can afford to wait until that time comes. The reader will, perhaps, say, "Well, and was not this conclusive proof, when the driver released the air valves on each carriage,

and the brake blocks still held firmly to the wheels—was not this proof that the brake was frozen?" And, no doubt, he will be astonished when I say, no, it was not proof. And for why? Well, reader, for this very simple reason: if the brake had been frozen, the driver would have been unable to apply it; and the brake blocks here show, unmistakeably, that the brake has been applied, and has done its work by stopping the train. The reader will, perhaps, say, "Then, if the brake is not frozen, why, in the name of wonder, can't it be released?" And I answer, it can, and, no doubt, has been released; but the brake blocks have not left the wheels, for a reason which I will explain to you. I have no doubt a great many of you, at some time or other, have amused yourselves, and, perhaps, other people as well, by sticking pennies or other coins to the walls, doors, or woodwork of the place you have been in at the time, by simply placing one edge of the coin to the woodwork or stone, and sharply forcing the flat part of the coin on to the wood, thereby forcing out the air from the back side of the coin, and causing a vacuum; consequently, the air on the other side, namely, the outer side of the penny, or whatever it may be, pressing on it with a pressure of almost fifteen pounds to the square inch, has held it firmly to the place, and prevented it from falling until the air found its way to the back side of the coin, when, by gravity, it falls to the ground. Just the same in this case of the automatic vacuum brake, which the newspapers have designated as freezing of the automatic brake, when it has been no such thing, but merely an incident, on a larger scale, similar to that of the penny. In applying the brake the driver has forced the blocks quickly to the wheels and expelled the air; and blocks and wheels being ground down to a very smooth surface by frequent application, the vacuum is not so easily destroyed as it would be with a rough and uneven coin; and if we take each block as nine inches long and three inches broad, and the air pressing on them with a pressure of fifteen pounds to the square inch, we see what a great amount of pressure has to be overcome before the engine is able to start its train; but anything which will tend to jerk the blocks will be attended with beneficial results—and this is only a similar case to many others which might be mentioned did space permit. But to get to the bottom of the thing, as to whether the automatic brake is a freezing machine, on a small scale, or not, we cannot do better than illustrate the method by which artificial freezing is accomplished, and study its bearing on the automatic brake.

CHAPTER X.

Letters of Eminent Men—How Artificial Freezing is accomplished—Inefficiency of the present Drip-Valves—What Drivers should be aware of in Frosty Weather.

FOR this purpose, we will take the experiments of eminent men, such as J. F. W. Herschel, Bart., and Mr. Charles May, who were instrumental in the discovery of artificial freezing; and I think the following letters which passed between them, and which were afterwards read to the Society of Arts in the year 1850, and afterwards published in the "Year Book of Facts" for 1851, will sufficiently explain the process of artificial freezing.

COLMWOOD, *December 24th.*

Without wishing to detract from the merits, or in any way to interfere with the claims of Dr. Gorrie, of Florida, in relation to his process for making ice by the expansion of highly compressed air, previously reduced to the ordinary temperature, as described in your *Athenæum* of Saturday, the 15th instant, I could wish to place on record, as a matter of scientific history, that on more than one occasion within the last four or five years I have explained orally to friends a process identical in principle as practically applicable to the manufacture of ice for sale on the great scale, the only question being that of remunerative cost as compared with that of importation. The annexed note, which I have received from my valued friend, Mr. May, will bear me out in this statement, so far back as February 11th, 1848, long prior to which, were it worth while, I could cite other testimony.

I am, &c.

J. F. W. HERSCHEL.

P.S.—An old steam-boiler, buried some twenty or thirty feet under ground, in well rammed earth, and furnished with a condensing-pump, worked above ground, and eduction-pipe opening by a stop-cock through a rose into water, would in all probability supply ice *ad libitum* for the use of a family in the country, the condensation being performed over-night.

IPSWICH, 12 *Mo.*, *20th*, 1849.

DEAR FRIEND,

I have a very clear recollection of our conversation on the subject of forming ice and cooling water for drinking purposes, and of thy suggesting that advantage might be taken of the re-absorption of heat by the expansion of condensed air that had been cooled to ordinary temperature in its compressed state. We agreed as to the possibility of its being done, but the probable cost appeared to me a difficulty in bringing it into practice.

P.S.—Whilst discussing this question, I remember repeating an account of a little experiment I made when a boy with one of Newmen's condensed air vessels, then just introduced for blowpipes. I had an idea that if a stream of condensed air were suddenly thrown upon sulphur, it would inflame the latter. Accordingly a vessel was filled with air almost to the limit of safety, and a roll of sulphur cautiously held to be ready for the opening of the stop-cock, when lo! instead of inflaming the sulphur, a small cone of ice was formed. The Chemnitz fountain has long since settled the practicability of so producing ice. The useful application of the principle is the point in question.*

* Dr. Gorrie's invention is noticed in the "Year Book of Facts," 1850 (p. 127).

We see, then, by the letters of these eminent men, who were instrumental in the discovery of artificial freezing, that two changes must be effected in the atmosphere, or air, before artificial freezing can be accomplished. The first is, that the air must be compressed, that is, the pressure of the air must be augmented by mechanical means; secondly, it must be cooled down to the ordinary temperature of the external atmosphere, generally termed condensation. Now, in the automatic brake no such process takes place; but this process is liable to take place in the Westinghouse, because the brake is worked by compressed air, while in the automatic vacuum brake the air is used at the ordinary pressure of the atmosphere, because the application of the brake is always external, that is, the air to apply the brake is always taken from the atmosphere at its natural pressure, and is not augmented by any mechanical means whatever, but is used in its natural state. Some clever critic might say: "Yes, but the air in rushing along the pipes gains force, and consequently when it comes in contact with the piston head, or diaphragm, of each cylinder, which is a resisting force, the air, by its onward rush and the momentum it has attained, is compressed by the onward rush of the air which is following up." But, instead of this being detrimental to the safe working of the brake, this onward rush of the atmosphere is an advantage to it. And for why? Because in its onward rush through the pipes the air becomes heated by friction, and we see by the experiments of these eminent men, Sir J. F. W. Herschel and Mr. Charles May, that before artificial freezing can commence, the air, besides being compressed, must be cooled down to the ordinary temperature of the atmosphere; consequently, the air having been heated in its passage along the pipes, even if it has been compressed to a slight extent by its onward rush, it must be cooled down to the ordinary temperature of the external atmosphere before artificial freezing can be accomplished, and long before this can occur, the extra pressure will have been taken off by the steam jet, or pump, which is continually at work extracting air from the pipes, while the application of the brake is only momentary; so we may confidently assert that according to all the laws of nature, the automatic brake is not a freezing machine, even on the smallest scale.

You may perhaps say, "Then does the automatic brake never freeze?" I say, no, never, when in action. But we have frequent cases of freezing when not in action, and the pipes being blocked with ice. "And what is the cause?" you will ask. The cause is owing to the present drip-valves not being efficient, which I should be glad to see remedied before the publication of this work. In the present drip-valves, the condensed steam which finds its way into the pipes, along with the water from other sources, is unable to make its escape through the drip-

valves until the brake is applied, and so the water lodge the pipes until the application of the brake, and then befo has time to escape through the drip-valves, it is caught by air in its onward rush through the pipes and carried forw sometimes to the highest part of them, and there lodges in bend of the pipe, and is unable to make its escape. Co quently, this water is left in the pipes to be frozen in the n when the train is standing in the siding with the pipes ope the external and freezing atmosphere, consequently it beco frozen and the pipes blocked up, or partly so, by ice; therefore I say to all drivers, beware of a train which does in frosty weather indicate in the guard's van the same amo of vacuum as quickly as it is indicated on the engine.

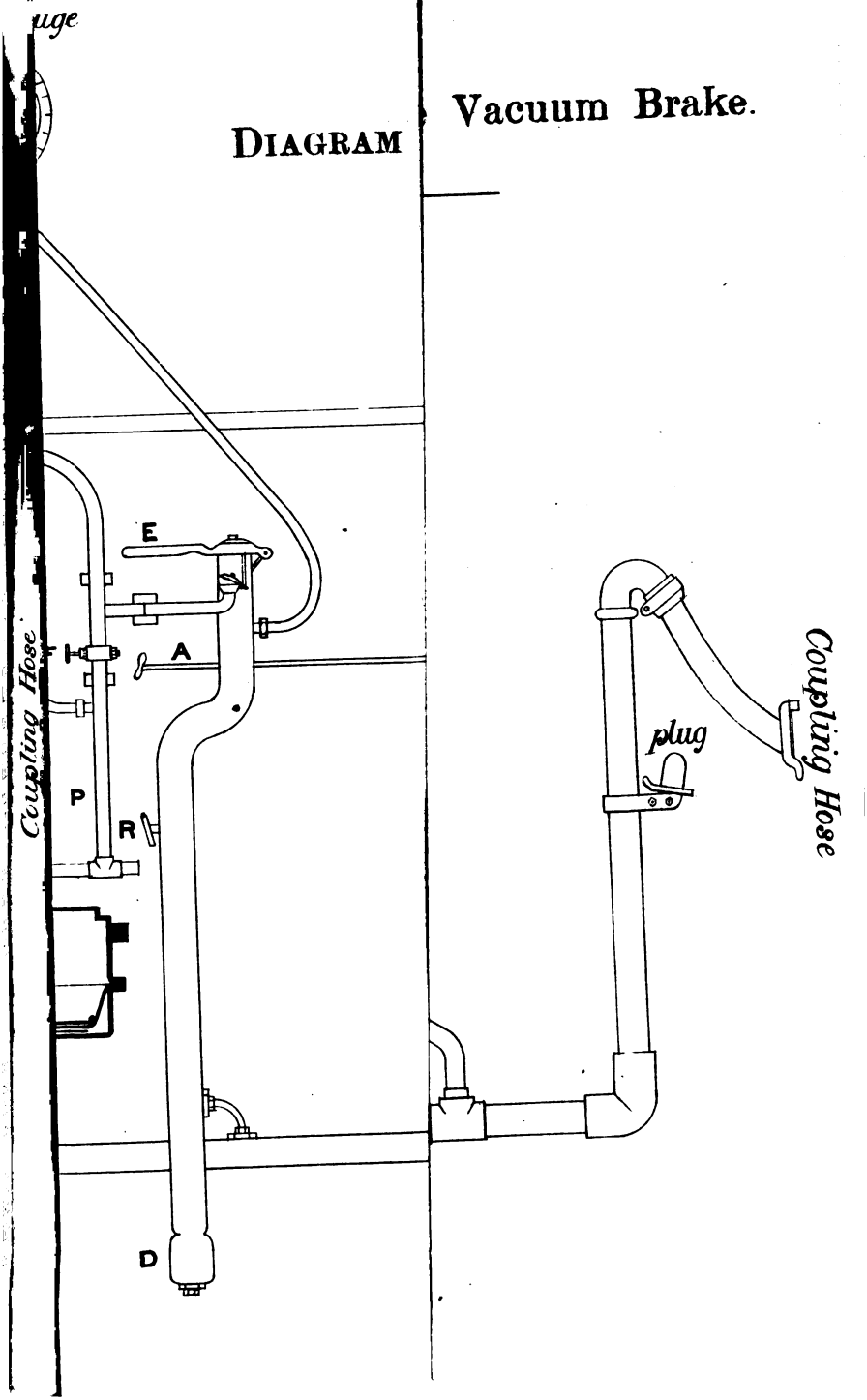
There is yet another point which I must mention in conn tion with the automatic brake and artificial freezing, which Brake Company provides for in its instructions relating to brake, and that is, when the train has been placed in the sid after having done its work for the day, the brakes are to released, and, in doing this, you must open one end of the tra pipe before releasing the brake. This will prevent the possibil of artificial freezing, which might possibly occur, although i highly improbable that it should, but it is always the best leave nothing to chance; and, therefore, as the driver alwa applies the brake before the main air-pipe on the engine detached from the main air-pipe of the train (this is done t make it more easy for the porter to uncouple the pipes; but even if the driver did not do this, the brakes would be quickly applied when the pipes were uncoupled), the onward rush of the air along the pipes would cause it to be slightly compressed, and if it was allowed to stand in the pipes until it had cooled down to the ordinary temperature of the external atmosphere, it might possibly produce artificial freezing. To prevent the possibility of this occurring, the brakes must be released with the main air-pipe open to the external atmosphere, so that as the air is admitted to the topside of each diaphragm, the extra pressure may make its escape through the main air-pipe to the external atmosphere, and thereby the possibility of artificial freezing is rendered void.

CHAPTER XI.

Mechanism and Action of the Brake—What a Driver should understand before he is allowed to take charge of a Passenger Train—Different kinds of Apparatus used for ejecting the Air—Combined Reversible, Simple, and Automatic Brake Engine—Why Drivers of Goods Engines prefer the Simple Vacuum to the Automatic Vacuum Brake.

HAVING gone into, and discussed the action of freezing by artificial means, we will now deal with the mechanism and action of the brake, which a driver should thoroughly understand before he is allowed to take charge of a passenger

DIAGRAM Vacuum Brake.



train, so that if anything goes wrong with his brakework he knows in a moment where to look for the failure, and also knows whether it is possible to remedy it or not, and consequently, by having a thorough knowledge of the brake, acts accordingly.

There are three kinds of apparatus used for ejecting the air from the pipes and cylinders, that is, there are three kinds generally in use by all companies who use the automatic vacuum brake. First: there are the ejectors which have been put on the old vacuum brake engines, the old ejectors being left on as well; then there is the combination ejector; and, lastly, the pump. Some of the old vacuum brake engines have been made into reversible, automatic, and simple vacuum, so that they can be worked with either brake by simply shutting or opening the perforated plug taps at the bottom of each brake cylinder, as shown in the drawings for converting valve, according to which brake you require to use. You can reverse the engine brake from simple to automatic vacuum, or *vice versa*, when standing on the footplate front, by pulling over the handles provided for that purpose, and marked respectively, at one side of its quadrant, S for simple vacuum, and at the other, A for automatic vacuum. Most drivers on goods engines prefer this class to the absolute automatic, for several reasons—less coal is used by them, and in foggy weather you can hear the shunters better by not having the constant blowing of the ejector in your ears, as is the case with the absolute automatic, and in addition to this consideration, when working simple vacuum, if you happen to get too much vacuum in the cylinders it can easily be destroyed and the brake released, which cannot be done so quickly with the automatic, and so the breaking of wagon drawbars is more frequent with the automatic than the simple vacuum.

Diagram No. 8.—Old vacuum brake engine converted into combined reversible automatic and simple vacuum. X is the small ejector fixed on the top of the fire-box and used for creating the vacuum when working automatic train. L is the large ejector which is used when working simple vacuum train, or to release the automatic brake more quickly. N is the exhaust valve-box for the large ejector. E is the application-valve used for applying the automatic brake, or, if working simple vacuum, to release the brake. C C are the cylinders, which are fitted with a perforated plug tap at the bottom of each cylinder, and a ball-valve; when the tap is open, the air enters through the perforations to the bottom side of the diaphragm and the brake then is simple vacuum, the air being extracted from the topside of the diaphragm only when applying the brake. D D D are drip-valves. Some engines now have four or five drip-valves; this is a pernicious practice, as each drip-valve weakens the power of the ejector in quickly re-creating the

standard amount of vacuum, and, if the drip-valves are at all worn, in maintaining it. P is the auxiliary pipe, which runs to the engine and tender brake cylinders only, and is connected to them by small flexible indiarubber pipes (marked G G) in direct communication with the top part of the cylinder. R is a pressure-valve, which has been introduced to prevent engines with powerful ejectors from obtaining more than the standard amount of vacuum; this was rendered necessary on account of engines with less powerful ejectors being unable to release and maintain the amount of vacuum at which the train had been worked by the engine which had run it the fore part of the journey.

Detailed description of the combined simple and automatic brake, showing the action of the steam and how it performs its functions.—Suppose a driver with a combination brake is going to work an automatic train. He first sees that the perforated taps at the bottom of each brake cylinder are closed; if so, the brake is right for working automatic, and he turns on steam to create the vacuum at the small ejector X, which is done by turning the small handle from a horizontal to a perpendicular position; this handle actuates a worm spindle and the valve which admits steam to the ejector is actuated by the worm so that it can be nicely adjusted to maintain the standard amount of vacuum at which the trains are run, and by shutting the steam-valve a driver can examine the automatic ejector when the engine is in full steam—the time it will take him to do so not occupying more than two or three minutes. The ejector itself is a cone in the inside of which is a disc valve provided with three prongs at each side of it to guide and balance it in the cone. The cone is pierced with three holes at its back end, and it screws into the exhaust pipe. When you open the steam-valve and admit steam to the ejector, it instantly closes the back stop-valve inside the barrel of the cone and immediately rushes round the barrel of the cone and enters the three before-mentioned holes at its back end, it then passes through the ejector, and, forcing the back stop-valve off its seat, rushes along the exhaust-pipe H into the smoke-box of the engine, and, by its suction, draws the air from the train-pipe and brake cylinders, through the auxiliary pipe, marked P, and, carrying it along the exhaust pipe, projects it into the smoke-box. You will notice that the auxiliary pipe connects with the main air-pipe, just below the application-valve, marked E, and over the connection is fitted a clapet-valve with lever attachment, and the application-valve has a prong fixed on the underside of the valve, which extends down to, and presses on the lever of the clapet-valve, so that, when the application-valve is shut, the prong rests upon the lever of the clapet-valve, and keeps the auxiliary pipe's connection open to the main air-pipe, and through this course the air is exhausted from the train-pipe and underside of diaphragms

We will suppose a driver, by the use of his small ejector, has obtained a vacuum of eighteen inches, the standard amount of vacuum at which the train is to be run; he is prevented from obtaining more, by the pressure-valve, marked R, which is set to resist a pressure of eighteen inches, or pounds to the square inch, therefore the atmosphere is pressing on it with its pressure of fifteen pounds to the square inch from the outside, and the steam jet has obtained a suction on the inner side of, say, a little over three pounds to the square inch. The resistance of the valve, then, not being equal to the combined forces of the atmosphere and suction of steam, the atmosphere forces its way into the train-pipe through the pressure-valve, until it again becomes equal and the vacuum gauge registers eighteen inches of vacuum, when the pressure and resistance are equal and the atmosphere is prevented from entering. Suppose the driver wishes to apply the brake, he raises the application-valve by the handle marked E, the air then rushes into the pipe and strikes the top of the clapet-valve and forces it firmly on to its seat, closing the airway to the auxiliary pipe. The air rushes forward along the main air-pipe and into the brake cylinders, the ball-valve of each cylinder is instantly pressed firmly on its seat, closing the airway to the topside of the cylinder, consequently, the air pressing on the underside of the diaphragm, meeting with little or no resistance, it forces the diaphragm up towards the top of the cylinder and applies the brake; if the driver then wishes to release the brake quickly, he opens the steam-valve of the large ejector L, by pulling at the handle A, and admits steam to the exhaust-valve box N, and the air, by the combined suction of both large and small ejectors, is rapidly drawn out of train-pipe and cylinders. He can, in addition to this, quickly equalise the vacuum in his engine and tender brake cylinders by opening the tap marked F, which admits air along the auxiliary pipe to the topside of each diaphragm. The opening of this tap does not, as some drivers suppose, admit air to the topside of each diaphragm throughout a whole automatic train—this assumption is ridiculous, because the auxiliary pipe only extends to the engine and tender brake cylinders, and some drivers who have had this explained to them will then assert that the pressure-valve acts in the same manner to the brake cylinders in the train as the tap does to the cylinders on the engine and tender. This shows that they have not even studied that action of the brake or they would surely know, that, by raising the pressure-valve by pressing it up with the finger, they are admitting air to the main air-pipe: how can it then equalise the vacuum in the cylinders of the train when it is admitted to the same airway that is used for the application of the brake?

Again, the drip-valves seem to be very little understood by a great many drivers—I mean the action of the drip-valve.

They seem to have no knowledge that drip-valves require extra power from the ejector to create and maintain the vacuum; but if a driver will just give his attention to the study of the subject for a few minutes, he will see what a detriment they are when carried to excess. We will suppose, for instance, we are dealing with an engine that has four or five drip-valves, —plenty of engines now having that number and upwards—you will see that if there is only a slight leakage from each valve, it considerably weakens the power of the ejector in creating or re-creating the standard amount of vacuum after it has been destroyed by the application of the brake—and drivers are well aware that to stop a train quickly, you must be able to apply the brake several times in rapid succession with full force, and the longer the ejector is in re-creating the vacuum the more it weakens the power of your brake, the extra pressure or vacuum which can be got in two or three moments by a good jet taking far more effect than is the case when the vacuum is low in train-pipes and cylinders. This is only natural, because the air which is in the pipes acts partly as a cushion or resisting force, preventing the incoming air gaining the velocity it would attain in rushing along a perfect vacuum, and of course its effect in striking the piston or diaphragm is much more feeble; therefore, drip-valves, if carried to excess, are a great evil instead of an advantage. and considerably weaken the effective power of the brake; in fact, I have seen engines with a good jet that have had five or six drip-valves, take from eight to ten seconds to create sufficient vacuum to raise the drip-valves. You must know that an inrush of air into the train-pipe through the drip-valve neck is the means by which the drip-valves are raised; so you will see that if you have several drip-valves, and your jet is at all weak, it takes it longer to create sufficient vacuum for the inrush to be strong enough to raise the valves and close the opening to the train-pipe. But the chief thing a driver wants to know, is, how to deal with failures; also how to detect where and what the failure is, by having a good knowledge of his brake.

CHAPTER XII.

How to tell when a Drip-Valve fails, and how to remedy the defect—How to deal with a Defective Joint—How to act in case a Flexible Pipe gets cut in two—Failure of the Auxiliary Pipe, and how to act—What the Brake Company's circular describes as the advantages of the Vacuum Automatic Brake—Misleading statements of the Vacuum Brake Company.

A DRIVER who wishes to understand and be prepared for any accident which may befall his brake tackle, and to quickly detect where and what it is, will ask himself such questions as these:—Providing a drip-valve failed to act, what would be the result? The answer should immediately be: I should be unable to again obtain a vacuum until the

defect had been remedied. The next question would be: How should I know that it was a drip-valve that had failed? The answer would be: Because I should be able to both hear and feel the air passing through the perforations at the bottom of the valve-box. And how should I act in this case—is it a thing I could put right myself, or would it totally disable the brake? Yes, I could put it right, and finish my day's work with the engine. Well, and how should I deal with it? Take off the cap and examine the valve, see what is causing it not to work properly, and remove the cause. How should I go on if the drip-valve was worn out—could I work home with an automatic train? Yes, by taking the valve out and corking up the inlet to the trainpipe, which the drip-valve would stop were it working properly.

The next question is: How should I act if a joint gave way in the main air-pipe? The answer would be: Wrap it firmly round with lamp cotton, or some other suitable material.

Providing the connecting-pipe at the smoke-box end of the engine through some cause or other got cut in two, could I still work an automatic train? Yes, by tying a piece of wagon sheet over the end of the pipe, doubling it two or three times, so that it would be able to stand the pressure of the atmosphere. Again, providing the flexible part of my auxiliary pipe got cut in two between the engine and tender, could I still work an automatic train? Yes, by either tying a cork inside the two separate ends of the broken pipe, or pulling the flexible pipe off altogether, and corking up the two separate ends of the metal pipe. But in this case you cannot rely on your indicator for vacuum chamber. Again, providing my small ejector could not maintain the vacuum, could I still work the train? Yes, by assisting it with the large ejector.

These, and various other questions, a driver should ask himself and test as opportunity occurs for him to do so, then whatever happens to his brakework, he is never at a loss to define the cause, and is instantly prepared to adopt the remedy, thereby saving his company unnecessary expense.

Having described the combined reversible brake we now come to the absolute automatic brake engine. The class we have been noticing can easily be turned into absolute automatic, by simply placing the reversing gear over to the automatic position, and then disconnecting it from the perforated plug taps, taking care to make the taps fast, so that they cannot be turned by the hand or by the shaking of the engine. Before going into the description of the absolute automatic brake, we will discuss what the Brake Company in their circular describe as the advantages of the brake. Firstly, "The vacuum automatic brake is instantaneous in its action, as air flows into the train-pipe at the rate of seven miles per minute." Probably this is correct, providing you have a

perfect vacuum. Secondly, "It can be applied to any numl of carriages." Thirdly, "It can be applied any number times in rapid succession without diminishing its power, whi is always retained, the vacuum in the upper part of t cylinders never being destroyed." Now this is likely to, a no doubt has led drivers astray time and again, and why t Vacuum Brake Company should so misrepresent the advantag of the brake I am at a loss to understand. The brake is goc enough without any puffing. Certainly the vacuum in tl vacuum chamber of each cylinder is never destroyed, bi saying the full power of the brake is never diminished is simpl ridiculous. For instance, we will say a driver has applied h brake several times in rapid succession, until the vacuum gaug indicator for train-pipe indicates from three to five pounds, c inches, of vacuum, that indicates that the vacuum in his trair pipe is from three to five pounds less than the pressure of th atmosphere, or, more definitely speaking, the atmosphere i the train-pipe is at a pressure of from ten to twelve pounds t the square inch, while the natural pressure of the atmosphere is a little under fifteen pounds to the square inch. Con sequently if the driver applies his brake again before he obtains a higher vacuum, he can only apply it with a pressure or force, of from three to five pounds to the square inch, which is the difference in pressure between the external atmosphere and the atmosphere in the train-pipes and cylinders of the brake. Enginemen should know that this low pressure would have very little effect on the brake, in fact, the result of the application would be almost imperceptible. It is high pressure which gives the best results, whereas the Vacuum Brake Company's circular would lead one to suppose that he had the best part of his brake power left in this vacuum of from three to five pounds to the square inch. Sixth, "The pressure is in all cases external; the joints are thus easily kept tight, and there is no tendency to burst the connecting-hose." Eighth, "There are practically no frictional surfaces, the piston being packed with a rolling-ring, the valve is a rolling-ball, no lubrication is required, and the working of the brake is not affected by dust or frost." I would recommend drivers to rub the piston-rods on engine and tender brake with dry waste, or otherwise the grit that accumulates on them in damp weather in minute portions wears both the piston-rod and ring. Next, the Vacuum Brake Company point out that the brake should be released slowly, to prevent skidding or jerky and unpleasant stopping. This is another mistake in the Vacuum Brake Company's circular, and I have no doubt in saying that all drivers know that the skidding of the wheels is never caused by releasing the brake, but, on the contrary, by applying the brake too quickly, and overcoming the velocity or tendency of the wheels to revolve.

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CHAPTER XIII.

Practical Description of the Absolute Automatic Engine and Tender Brake with Combination Ejector, showing the action of the Steam in creating the Vacuum; also the course through which the Air is drawn from Train-Pipes underside of Piston and Vacuum Chamber; also the action of the Ball-Valves at the bottom of Brake Cylinders—How to work the Brake, and how to detect and remedy failures which come within the ordinary scope of the Engineman.

DIAGRAM No. 9.—Absolute automatic brake. S is the steam-valve; E, the steam-pipe through which steam passes to the combination-ejector N; X is the exhaust-pipe, running from the combination-ejector to the smoke-box of the engine; H is the driver's handle, used for applying and releasing the brake; V is the vacuum gauge; A, the auxiliary pipe; C, the clapet-valve covering the top of the auxiliary pipe's connection with the main air-pipe; L L are the two brake cylinders; B B, the ball-valve boxes at the bottom of each brake cylinder; M M, small flexible pipes connecting brake cylinders with main air-pipe; D D are drip-valves; P P, the piston rods; G G, the main air-pipe; R R, universal coupling used for coupling on to train-pipe, or the solid plugs marked O O; Q is the pressure-valve.

The first action of the automatic brake that is worked by a jet of steam, similar to diagram, is the turning on of the steam at the steam-valve S, which is done by turning the wheel, or tap, from left to right. The steam then rushes down the steam-pipe, enters the combination-ejector N, passes round the cone of the small ejector, and then enters the barrel through the three holes at its back end, rushes through the ejector, passing round the back stop-valve, which is in the barrel of the cone. I have told you previously that the back stop-valve has three prongs on each side of it to keep it square in the barrel. Well now, this stop-valve should always work freely, or otherwise the steam which should pass through the barrel of the cone, and thence along the exhaust-pipe into the smoke-box, takes the wrong way, and rushes down the auxiliary pipe A into the brake cylinders of the engine and tender brake. You can easily tell when the back stop-valve is not working properly, because the auxiliary-pipe gets hot with the steam passing through it, and remember it should always be cold. The reason of the valve sticking nine times out of ten is through the three prongs at the front end of the stop-valve having got expanded, so that they fit too tight in the barrel of the cone; and the only way to remedy it is to take out the ejector, screw off the end, take out the valve, and ease it by filing a trifle off the outside of each prong, so that it will work

freely in the barrel of the cone. Care must be taken in replacing the valve in the barrel to have the three longest prongs towards the front end of the ejector, or otherwise the ejector will not work I may mention that this is a thing which seldom occurs, and therefore there is all the more reason for a driver to take particular note of it, so that he knows how to act if a similar case ever falls to his lot. When the steam begins to rush through the barrel of the ejector, it creates a vacuum, or suction, and the air in the cylinders and train-pipe, being an elastic substance, is easily induced to follow.

But what drivers chiefly want to know is, through what course the air is drawn out of the train-pipes and cylinders, and how the ball-valves are affected at the bottom of each brake cylinder, and the various other valves connected with this admirable piece of mechanism. The reader must then understand that when steam is turned on at the steam-valve S, it passes through the ejector in the manner previously described, and, by its suction, creates a vacuum in the train-pipe by withdrawing the air. This vacuum instantly affects each drip-valve in the drip-valve boxes of engine and tender brake. The question then is, how are the valves affected by this vacuum, and what is their action under its influence? To explain this, we must explain the position of the drip-valves when there is no vacuum in the train-pipe. The valves, then, lie at the bottom of the valve-boxes, which are perforated, and, the ball-valve not being able to cover all the holes, the water has a clear course to drain out of the pipes through the valve-boxes and out at the perforations; but as soon as a vacuum is created in the main air-pipe, the external atmosphere begins to rush through the perforated plugs at the bottom of each drip valve box, endeavouring to destroy the vacuum which is being created in the pipe, and the drip-valve is instantly caught by this inward rush of air and carried up to its seat, closing the inlet to the main air-pipe and preventing the external atmosphere from entering. Consequently, the air being baulked in its endeavours to enter the train-pipe, it keeps the valve pressed firmly to its seat, pressing on the valve with its pressure of fifteen pounds to the square inch; but so soon as the vacuum in the main air-pipe is destroyed by the application of the brake, or damage to any of its parts—we will say by the application of the brake—the air is admitted to the inside of the pipe, and, rushing along the pipe, it equalises the pressure on each side of the drip-valve, which, by gravity, again falls to the bottom of the valve-box, its normal position; but so soon as you cease to apply the brake, the valves are again caught by the external atmosphere as before, and carried on to their seat in a similar manner.

We will next describe the course through which the air is drawn out of the train-pipes and cylinders. You must under-

stand, then, that the air from the vacuum chambers of the engine and tender brake cylinders is drawn through the auxiliary-pipe A direct by the small ejector, while the air from the train-pipe and bottom part of the cylinders is drawn through the auxiliary-pipe's connection with the main air-pipe, which is governed by the clapet-valve C, and thence passes through the ejector. The large ejector draws the air out along a different course altogether. If the large ejector is used for creating the vacuum, it draws the air along the main air-pipe, and, by its suction, draws the ball-valve at the bottom of each cylinder off its seat, drawing the air from the topside of the piston past the valve, until the vacuum chamber is exhausted of air. When this is accomplished, there being then no force of air passing the ball-valve, the suction of the ejector alone is unable to keep it at the top of the incline, consequently the valve rolls back on to its seat, and closes the entrance to the vacuum chamber, which will then register by the vacuum-gauge the amount of vacuum, the vacuum gauge being connected with the auxiliary-pipe for vacuum chamber part of the cylinder, and for the bottom part of the cylinder with the main air-pipe

You will have noticed that the handle marked H in the diagram has nothing whatever to do with the small ejector, which is solely controlled by the admission of steam from the steam-valve S, and the ejector is set to create and maintain the standard amount of vacuum. The steam-valve should always be kept open when running a train. Even when applying the brake the small ejector is useful, if the ball-valves happen to be worn in engine and tender brake cylinders, because it is continually keeping up the vacuum in the vacuum chambers of the engine and tender brake cylinders, drawing the air through the auxiliary-pipe's connection with the vacuum chamber, which is behind the ball-valve. You will see by this that if your auxiliary-pipe chanced to get cut in two, your vacuum gauge handle, which indicates the amount of vacuum in the vacuum chamber, namely, the handle on the right hand of the gauge, would immediately fall to zero, and the indicator for train-pipe would be gradually falling to the same level, so you would know in a moment that something had happened to your auxiliary-pipe; whereas, if anything had happened to your train-pipe, your indicator for vacuum chamber would indicate the full amount of vacuum, while the indicator for train-pipe would fall to zero, and the atmosphere having gained access to the train-pipe direct, the brakes on the whole train would be instantly applied and the train brought to a stand.

This, you must agree, is a grand thing for the safety of the precious freight in our passenger trains. If either of the two mentioned accidents should happen when you were

at a distance from your terminal, a driver should know wh to do at once, and not give up his train, when, by having knowledge of his brake, he could work home. Therefore, thorough knowledge of the brake is imperatively necessary f passenger drivers, so as to save unnecessary and vexatio delays to the public and railway managers, leaving alone t cost to the company, which is often considerable.

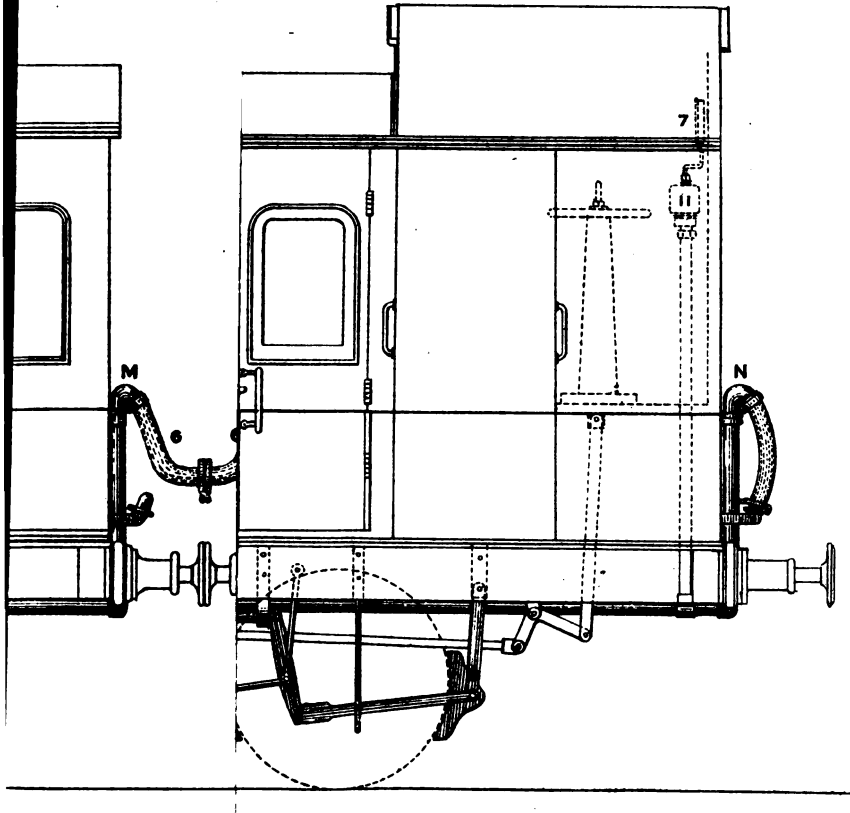
Now, if a driver who understood his brake had an accid with his auxiliary-pipe, he would cork up the two separate en of the pipe, taking care to make them perfectly airtight, and could still use his small ejector, assisting it, if need be, by t large ejector, taking care to always have the vacuum well up, he would only have one indicator to rely on, his vacuum cham indicator being unreliable. Now, if it happened to be a jo in the main air-pipe that gave way, his difficulty would not so great. He would merely have to wrap it round with la cotton, or some other pliable material, greasing it well w tallow or fat, so as to make it airtight. But whatever happe a driver having studied what can be done, a remedy w suggest itself which is easy to accomplish.

The next action is the application of the brake, which done by pulling the handle marked H in the diagram towa you. By this action, you move the solid part of the perfora disc from off the opening to the main air-pipe, which has covered, and bring over the perforated part, the immediately rushes through the perforations and along main air pipe, closing the clapet-valve C, and enters bottom part of the brake cylinders through the flexi connections M M, but is prevented from getting to the tops or vacuum chamber, by the ball-valves at the bottom of e brake cylinder. Consequently the vacuum in the vacu chamber is retained, and the air, pressing on the unders of the diaphragm, forces it up towards the top of cylinder, and thereby applies the brake by twisting the bra shaft partly round by the suitable and well-known br appliances.

CHAPTER XIV.

THE Automatic Vacuum Brake as an Invention—Should Drivers study Mechanical and Scientific Principles—What Railway Directors Mechanical Engineers would do well to insist upon—Drawing complete Automatic Train, with Technical Description—Each Carri a separate Brake in itself, and yet continuous—Description of Valve in the Guard's Van.

HAVING seen how the brake is constructed and work on automatic brake engines, we now come to a f automatic train, which has been, and still is, a marv of ingenuity to the travellers on our railways; and they vie it with wonder and amazement, it being one of the most skilfu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scientific inventions of modern times, giving to man power over the forces of nature, so that they are subservient to his slightest wish, giving him advantages over past generations of railway travellers, which were neither dreamt of nor surmised by them. Then, who shall say that the world is not progressing, when we of this generation have seen such inventions as this, aye, and what is better, reap the advantages of it in the cheap transit of merchandise and human freight, the which it would have been impossible to attain without the aid of these inventions of mechanical science? And, what about the drivers who have control of this great invention, and in whose hands are placed the lives of hundreds of human beings? Should they not study its minutest details, and make themselves masters of its mechanical and scientific principles? Aye, and the man who neglects to do so is unworthy the position, and should be disqualified without compunction, if the means of gaining this knowledge is within his reach, and he neglects to avail himself of it, either through mercenary considerations or lack of energy, and both railway directors and the mechanical engineers on our railways would do well to insist upon this knowledge being attained before a driver is allowed to take charge of a passenger train; if not in their own interest, they should insist upon it in the interest of the precious lives entrusted to their care in our passenger trains.

In dealing with an automatic train, as in dealing with other classes of automatic and simple vacuum brakes, you have, as it were, to repeat yourself over again, and it is impossible to avoid this and yet give a clear and definite description of the minor details in which brakes on different engines vary in their mechanical arrangements; and were not these explained in detail, the reader would gain but an imperfect knowledge of the simple and automatic vacuum brakes.

Diagram No. 10.—Complete automatic engine and train. S is the steam valve through which steam is admitted from the boiler to the combination injector marked G; H is the handle used for applying the brake, or to bring into use the large ejector; T is the exhaust pipe; D D are the drip-valve boxes; L L L L are the brake cylinders; P P P P are the piston rods; R R R R are the brake levers, and those marked X are the brake blocks; M M M is the main air pipe, which is coupled on to the solid plugs at N N, the two opposite ends of the pipe, namely, the front of the engine and the tail end of the train, making an airtight connection, and complete automatic train.

Technical description of the brake's action when working—i.e., creation of the vacuum and application of the brake, showing the action of the ball valves and drip valves, and the whole of the brakework in general.—When it is desired to put the brake into action ready to work the train, you turn steam on at the steam-valve S, the steam then passes down the steam-

pipe to the combination-ejector G, passes round the cone of the small ejector and enters the barrel through three half-inch holes at its back end, forcing the back stop-valve off its seat, passes round it and rushes along the exhaust pipe T, and thence out of the smoke-box funnel, and by its suction the clapet-valve, which is placed just below the combination-ejector, is opened; this clapet-valve, you will remember, covers the top of the auxiliary pipe's connection with the main air-pipe, and when it is open the connection is established between the auxiliary-pipe and the main air-pipe, and through this course the air from the main air-pipe, and also the bottom or underside of the brake cylinders, is withdrawn by the small ejector, while that which is in the vacuum chambers of the engine and tender brake cylinders is drawn through the auxiliary-pipe direct, and is not affected by the clapet-valve, but is always under the full power of the ejector and is thus kept at a high vacuum You will see by this that when the clapet-valve is open the ejector is extracting air from the train-pipe, and also from the underside of the pistons along the whole train.

Let us then assume that the ejector is at work, and by its suction has opened the clapet-valve, and is drawing or withdrawing the air which is in the train-pipe and bottom part of brake cylinders. So soon as ever the ejector commence to do this it causes a rush of air through the drip-valv boxes, the valves are forced on to their seat, and the extern atmosphere is prevented from entering the train-pipe; the fu power of the ejector is then given to the extraction of the a which is in the brake cylinders and train-pipe along the who train. No matter whether it be a train of two or of twen carriages, as soon as the ejector commences to extract the a the ball-valve at the bottom of each brake cylinder is draw off its seat, and the air which is in the vacuum chamber *i.* that part of the cylinder which is above the diaphragm, th air is drawn past the ball-valve and the vacuum chamb rapidly exhausted of air. When this is accomplished the being then no force of air passing the ball-valve, which is the top of the incline, the suction of the ejector alone is unab to keep it in this position, and the ball-valve rolls back dow the incline on to its seat, closing the inlet to the vacuu chamber. Now, this vacuum in the vacuum chamber after has been once created is kept intact until such time as yo open the valve provided on each brake cylinder for i destruction. The valve provided for this purpose admits a when it is opened, to the pipe connecting with the vacuu chamber, just behind the ball-valve, and destroys the vacuu It is impossible to destroy the vacuum in the vacuum chambe of the train cylinders without opening the valve provided fo this purpose on each brake cylinder, and the vacuum in eac

[illegible]
purpose on each brake cylinder, [illegible]

vacuum chamber is governed by its own valve; so that you can destroy the vacuum in each separate carriage without interfering with or affecting that of the others, each carriage being what you might term a separate brake, and yet, when in action, continuous throughout the whole train.

You have now seen how the vacuum is created in a complete train, and how the ball-valves are affected at the bottom of each cylinder, &c : we will now notice their action under a destruction of vacuum by the application of the brakes.

When the driver wishes to apply the brake he pulls towards him the handle marked H in the diagram. By this action he moves the solid part of the disc from off the inlet to the main air-pipe, and brings the perforated part over; the air rushes through the perforations and into the main air-pipe, striking the clapet-valve and forcing it firmly on to its seat; rushing along the main air-pipe it equalises the pressure on each side of the drip-valves, which by gravity fall to the bottom of the valve-box. The air passing on enters the bottom part of each brake cylinder, and striking the diaphragm forces it up towards the top of the cylinder; the piston rod P, being connected with the lever R of the brakework, in rising slightly twists the brake shaft, thereby pulling the brake blocks marked X to the wheels, and applies the brake with great force; in this as in other cases the air is prevented from getting into the vacuum chamber by the ball-valve at the bottom of each brake cylinder. When you cease applying the brake the suction of the ejector again opens the clapet-valve, and commences to extract the air from the main air-pipe and underside of the pistons, the drip-valves being forced on to their seat as before, and the ejector rapidly re-creates a high vacuum in the train-pipes and cylinders; but if it is desired to create the vacuum very quickly, the large ejector is brought into play as well, by simply pushing the handle marked H over to the opposite extreme or position marked "brake off," when steam is admitted to the large ejector, and passing through it in the manner previously described quickly re-creates a high vacuum. The brake can also be applied by the guard independently of the driver by the valve which is in the guard's van; this valve, diagram No. 11, is fixed on the main air-pipe, and enables the guard, by pressing down the handle marked L, to apply the brake. This valve also opens automatically when the driver applies the brake suddenly, and it then admits air until the brake is fully applied. When this has been accomplished the valve again assumes its original position and closes the inlet to the main air-pipe—this is accomplished by gravitation.

Technical description of the valve.—This valve has a small hole through its stem, and is secured at the top by a diaphragm to a small dome-like chamber. This chamber is

exhausted of air when a vacuum is created in the train or main air-pipe, and if a gradual application of the brake is made by the driver the vacuum in this chamber is destroyed in the same ratio as that in the train-pipe; but should the brake be applied suddenly, the vacuum beneath this valve is destroyed much quicker than that in the train-pipe, and then the pressure of the atmosphere on the diaphragm lifts the valve, which then remains open until the vacuum in the dome-like chamber has been destroyed by the air which enters through the small hole marked E, when it again closes by gravity. The guard has also a vacuum gauge in his brake van, which indicates the amount of vacuum throughout the train.

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